RESIDENTIAL CATTLE EGRET COLONIES IN TEXAS: GEOGRAPHY, REPRODUCTIVE SUCCESS AND MANAGEMENT

A Thesis

by

MICHAEL LAWRENCE PARKES

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2007

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Co-Chairs of Committee,	Miguel A. Mora
	William Grant
Committee Member,	Rusty Feagin
Head of Department,	Tom Lacher

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ABSTRACT

Residential Cattle Egret Colonies in Texas: Geography, Reproductive Success and Management. (August 2007)

Michael Lawrence Parkes, B. S., Virginia Tech

Co-Chairs of Advisory Committee: Dr. Miguel A. Mora
Dr. William Grant

A phenomenon of large, upland breeding colonies of cattle egrets in residential areas of Central Texas has been observed since the early 1960s. These large concentrations of breeding birds can be a nuisance to nearby residents and their management has been difficult. To help understand why cattle egrets choose upland, residential breeding sites, and predict where these might occur, the geographic extent of the phenomenon was bounded within Texas, a habitat suitability model constructed, and reproductive success compared by breeding habitat type to evaluate if residential nesting confers an adaptive advantage..

Records of upland cattle egret colonies were found only in Central Texas, not other parts of the state. The habitat suitability model was constructed using total edge of three land use classes: water, forest, and developed classes. The model classified 78.6 % of upland colonies in very high or high suitability classes and 7.1% of colonies in low or very low suitability classes. This distribution was significantly different than expected considering the overall ratio of suitability scores in the entire raster model ($p = 0.036$).

Nineteen active colonies were found in or bordering the Post Oak Savannah and Blackland Prairie ecoregions. Colonies were in residential, urban, island, and flooded

tree and shrub habitat. Nests were found in 12 different tree and shrub species. Residential colonies had more breeding pairs, greater nest survival, and were less productive than non-residential colonies on average, but these differences were not statistically significant. Colonies where nest substrate was removed were not reused and no breeding was initiated nearby the next year. Propane cannons discouraged reuse of colony after prolonged application.

Herons and egrets likely use residential sites when wetland habitats are limited. Their overall breeding distribution reflects state wide rainfall and wetland availability patterns with upland nesting in Central Texas, wetland nesting in eastern and coastal regions, and little large scale nesting in western Texas. Egrets and herons may use edges of development as breeding sites to limit predation by ground predators when flooded tree and shrub or island habitats are absent, but this hypothesis needs more testing.

DEDICATION

This work is dedicated to the memory of Lawrence Norman Parkes (1945-2000).

ACKNOWLEDGEMENTS

I would like to thank Dr. Miguel Mora for his guidance and assistance during all phases of this work. He deserves substantial credit for its success. I would like to thank the rest of my committee for their valuable contributions. In addition, I thank Dr. David Phalen for his presence on my committee.

This project would not have been possible without the cooperation of private landowners granting access to their properties. These landowners include Mick Robinson, Gene Hillman, Stanley Glaser, Randy Hughes, Roger Sturdevant, New Rattlesnake Ranch, Judge Mature, Lois Kmeic, David Gerber, Heard Museum, San Antonio Zoo, Davey Smith, Ace Fairchild, Trinity Mine, and Sara Hilger.

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CHAPTER I

INTRODUCTION

Since the cattle egrets' (*Bubulcus ibis*) apparent natural introduction to the western hemisphere from Africa circa 1900, and the first Texas record in 1954, their range and population have expanded tremendously in North America (Telfair 1983; 1994; Telfair et al. 2000*a*). Their current range now encompasses most of the contiguous United States, but after an initial exponential increase, their population appears to have stabilized or may be declining (Davis 1960; Crosby 1972; McCrimmon et al 1997; Telfair et al. 2000*a*; B. Ortego, Texas Parks and Wildlife, unpublished data). The phenomenon of cattle egret invasion is global, with establishment of populations on all continents, except Antarctica, and colonization of many oceanic islands (Crosby 1972; Siegfried 1978; Voisin 1991).

The cattle egret is thought to have maintained an ancestral range limited to the Old World tropics, likely Central Africa (Siegfried 1978). Within this range cattle egrets occupy a broad niche, capable of feeding upon both terrestrial and aquatic prey. In Central Africa cattle egrets mainly rely upon freshwater wetland habitats that are ephemeral, their creation and size depending upon seasonal variation in precipitation. Abundant precipitation during the rainy season produces a mosaic of wetlands, unpredictable over time and space. Edges of these wetlands attract large herds of grazing ungulates, mainly African buffalo (*Sycerus caffer*). This environment is similar to present day Central Texas where most permanent wetlands are limited to major river systems, ephemeral freshwater wetland creation is dependent upon seasonal and annual

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This thesis follows the style of The Southwestern Naturalist.

fluctuations in precipitation, and large populations of grazing ungulates in the form of cattle (*Bos taurus*) are attracted to the edges of wetlands.

Beginning with the first inland Texas cattle egret breeding record in 1961, cattle egrets have established large colonies in upland, residential areas of central Texas mixing with native species of herons and egrets (Telfair 1981*b*; Texas Colonial Waterbird Society 1982; Mora and Miller 1998; Telfair et al. 2000*b*). These colonies can contain thousands of nests, the majority usually are cattle egret, with little blue heron (*Egretta caerulea*) pairs, snowy egret (*Egretta thula*) pairs, or both, always present (Telfair 1981*a*; Telfair et al. 2000*b*; pers. observ.). Other species, such as great egret (*Ardea alba*), black-crowned night-heron (*Nycticorax nycticorax*), anhinga (*Anhinga anhinga*) and additional species of wading birds nest at some sites. In Texas, large, residential heronries are mainly located within or bordering the Post Oak Savannah and Blackland Prairie ecoregions (Telfair et al. 2000*b*). Other residential heronries have been reported in Alabama, Oklahoma, New Mexico, California, and India (Dusi et al. 1971; Rao et al. 1996; Bill Howe, USFWS, pers. comm.; pers. observ.).

Some residential heronries are labeled a nuisance due to high densities of nesting birds producing noise and odor problems for human residents and guano damaging or destroying nesting trees and shrubs (Dusi 1977; Dusi 1979; Mora and Miller 1998; Telfair et al. 2000*b*). Egrets and herons engage in facultative brood reduction (consistently, more eggs hatch than chicks fledge) via food provisioning and siblicide (Mock et al. 1987; Voisin 1991). This results in many chicks dying within the colony without fledging. Presence of these dead chicks, occasional dead adults, thousands of

live birds, and massive guano deposition, has led to public perception of colonies as a potential human health risk.

Bird colonies can be reservoirs of diseases such as psittacosis-ornithosis, histoplasmosis, arboviruses, and salmonella (Telfair et al. 2000*b*). It has been discovered that egrets and herons may carry diseases that could be transmitted to humans, although no direct evidence of transmittal is known (Telfair 1983). Agents causing psittacosis-ornithosis, a pneumonia like disease, have been isolated from herons and egrets in Texas (Rubin et al. 1951; Moore et al. 1959). Preliminary studies by Texas A&M University researchers suggest a point prevalence of salmonellosis of 25-90% in cattle egret nestlings (D. Phalen, Texas A&M University, unpublished data). Some of the identified strains are highly pathogenic. There is no scientific evidence suggesting transmission of disease from heronries to humans.

Management of nuisance heronries has been difficult. Nesting herons and egrets are protected by the Federal Migratory Bird Treaty Act, as well as Texas state law, and harassment of nesting birds is illegal unless proper permits are secured (Telfair et al. 2000*b*). Most techniques employed in discouraging reuse of established heronries has involved disturbance of birds arriving at the heronry before nesting has initiated, or altering or removing nesting vegetation in the absence of breeding birds. Scare tactics such as noise, streamers, lights, smoke, spraying with water, balloons, and hawk silhouettes have been used (Dusi 1979; Telfair 1981*b*; Booth 1983; Telfair et al. 2000*b*). These tactics have been variable in preventing reestablishment of heronries and disturbed birds may establish new colonies in suitable sites nearby or recolonize sites in

future years (Telfair 2000*b*). Management techniques have not been developed that adequately address concerns of residents, remedy nuisance problems without displacing them, treat birds humanely, and keep nesting vegetation intact. Lethal control has not been effective (Dusi 1979).

Why herons and egrets nest in residential areas of Central Texas is largely unknown. Controlling factors in the evolution of colonial nesting have been difficult to evaluate (review in Danchin and Wagner 1997). Prevailing theory focuses on the assumption that coloniality should evolve when its net benefits are greater than those of solitary nesting. Numerous variables are contained in this ideal cost/benefit analysis. Wittenburger and Hunt (1986) summarized the net effect of these variables into 4 factor groups: predation, enhanced energy acquisition, access to mates, and opportunities to disrupt neighboring conspecifics. Variables within these factor groups could have mixed effects on overall cost/benefits of coloniality. For instance, colonial species may gain protection from predators through increased vigilance of a group while simultaneously attracting more predators to their location due to increased prey density. Group factors thought to control formation of mixed-species heronries are predation and enhanced energy acquisition (Burger 1981; Forbes 1989; Kopachena 1991).

The objective of this research is to explore and describe the historic and current geographic extent of residential heron and egret colonies in Central Texas and evaluate relevant factors in site selection. Repeated colonization and use of residential areas for breeding in Central Texas suggests an adaptive advantage to these areas over surrounging areas of other types (Orians and Wittenburger 1991). A broad search for

colonies was conducted within the region and an evaluation of reproductive success was undertaken in an attempt to uncover adaptive advantage to residential reproduction. In addition, a model using Geographic Information Systems (GIS) was created to identfy factors prefered in the establishment of upland colony sites and attempt to predict under what circumstances they might form in the future.

CHAPTER II

LARGE UPLAND CATTLE EGRET COLONIES IN TEXAS: GEOGRAPHIC EXTENT AND HABITAT SUITABILITY MODEL

Synopsis

A phenomenon of large, upland breeding colonies of cattle egrets in residential areas of Central Texas has been observed since cattle egrets were introduced to the region in the early 1960's. Large concentrations of breeding birds can be a nuisance to nearby residents. In this chapter the geographic extent of the phenomenon is bounded and factors influencing colony site selection are considered and used to construct a habitat suitability model. Records of upland cattle egret colonies were found only in Central Texas, not in East Texas or along the Gulf Coast. In those regions only records of nesting in flooded trees and shrubs or on islands were found. This suggests that these habitats are preferred for nesting over upland sites and upland sites are only used when wetland sites are limited. The habitat suitability model was constructed using total edge of 3 land use class types; water, forest, and developed edge. The model classified 78.6% of 14 upland colonies in the very high or high suitability classes while 7.1% of colonies were in the low or very low suitability classes. This distribution was significantly different than expected values from the overall classified raster model ($p = 0.036$). Egrets and herons may use edges of development as breeding sites to limit predation by ground predators when flooded tree and shrub or island habitats are absent, but this hypothesis needs more testing.

Introduction

Beginning with the first inland Texas cattle egret breeding record near Waller in 1961, cattle egrets have established large colonies in upland areas of central Texas, mixing with native species of herons and egrets (Telfair 1981*b*). Large, upland residential heronries have mostly been reported within or bordering the Post Oak Savannah and Blackland Prairie ecoregions of the state (Texas Colonial Waterbird Society 1982; Mora and Miller 1998; Telfair et al. 2000*b*). These colonies can contain thousands of breeding pairs of wading birds, mostly cattle egrets (Telfair 1981*a*; Telfair et al. 2000*b*; pers. observ). Other residential upland cattle egret heronries have been reported in Alabama, Oklahoma, New Mexico, California, and India (Dusi et al. 1971; Rao et al. 1996; Bill Howe, USFWS, pers. comm.; pers. observ.).

Large colonies of wading birds produce noise, odor, massive amounts of guano, and dead chick and adult bird bodies (Dusi 1977; pers. observ.). These conditions in close proximity to human habitation cause these colonies to be labeled a nuisance and create a perception they're potential vectors of disease (Dusi 1979; Telfair et al. 2000*b*). Nuisance colonies are typically in upland habitats as opposed to the more wetland habitats normally associated with wading bird colonies.

Colonies serve as breeding sites for multiple pairs of birds, and research suggests that species specific requirements in site characteristics may be important in the process of colony site selection (Farinha and Leitao 1996). The relative influence of factors controlling breeding locations of colonial birds remains unresolved, but factors thought to control the formation of heronries are predation and enhanced energy acquisition

(Burger 1981; Forbes 1989; Kopachena 1991). Selection of colony sites by wading birds is thought to be driven by predator avoidance at fine scales (Dusi et al. 1971; Rodgers 1987; Frederick and Collopy 1989*b*). The surrounding landscape matrix may also be an important factor in determining colony formation and location, as foraging areas for some heron species are known to extend 15 km or more from their nesting sites (Gibbs and Kinkle 1997; Tourneq et al. 2004).

Ecologists and wildlife managers have shown a keen interest and need for information and theory regarding habitat selection and use in birds (Grinnell 1917; Jones 2001). Recently, the development of technologies such as Geographical Information Systems (GIS) and remote sensing have enabled researchers to examine habitat selection in powerful ways across landscapes (Guisan and Zimmerman 2000; Naugle et al. 2001). These techniques promote construction of models which are both descriptive and predictive in nature.

The objectives of this chapter are to evaluate landscape factors that might influence where residential heronries occur in Texas by bounding the phenomena of upland heronries then creating a habitat suitability model to predict where these colonies might occur.

Study Area

The entire state of Texas was considered for collecting locations of large breeding colonies of cattle egrets. This state is incredibly diverse in habitats, containing 10 ecotypes ranging from forest and coastal plain to mountains and desert (Fig. 2.1) (Gould 1975). Texas has been significantly impacted by human development, especially in land

uses related to agriculture and urbanization and in the distribution and management of water resources (Schmidly 2002).

The analysis area for a habitat suitability model was determined by the geographic extent of upland heronry records within the state.

Methods

Data Layers

An extensive effort was made to collect records of colony locations with at least 100 cattle egret nests. The main sources for these records were the Atlas of Texas Waterbird Colonies, data provided by Texas Parks and Wildlife Department (TXPWD), and a few scientists (TXCWS 1982; Brent Ortego TXPWD; Ray Telfair pers. comm.; David Phalen, Texas A&M University; pers. comm.) These locations were collected using different methods including aerial and ground surveys, colonies discovered opportunistically by birders and agency personnel over a period of decades, paper maps and Geographical Positioning Systems (GPS). In addition to these historic records, an extensive ground survey for active colonies was performed by the author during the breeding seasons of 2005 and 2006, mostly in the Post Oak and Blackland Prairie ecoregions of Central Texas. This sample of locations is not intended to be comprehensive, as complete wading bird colony surveys of the state are rarely made, and are usually performed regionally and sporadically (Brent Ortego, TXPWD, pers. comm.). Instead this sample is thought to reflect the types of habitats where colonies

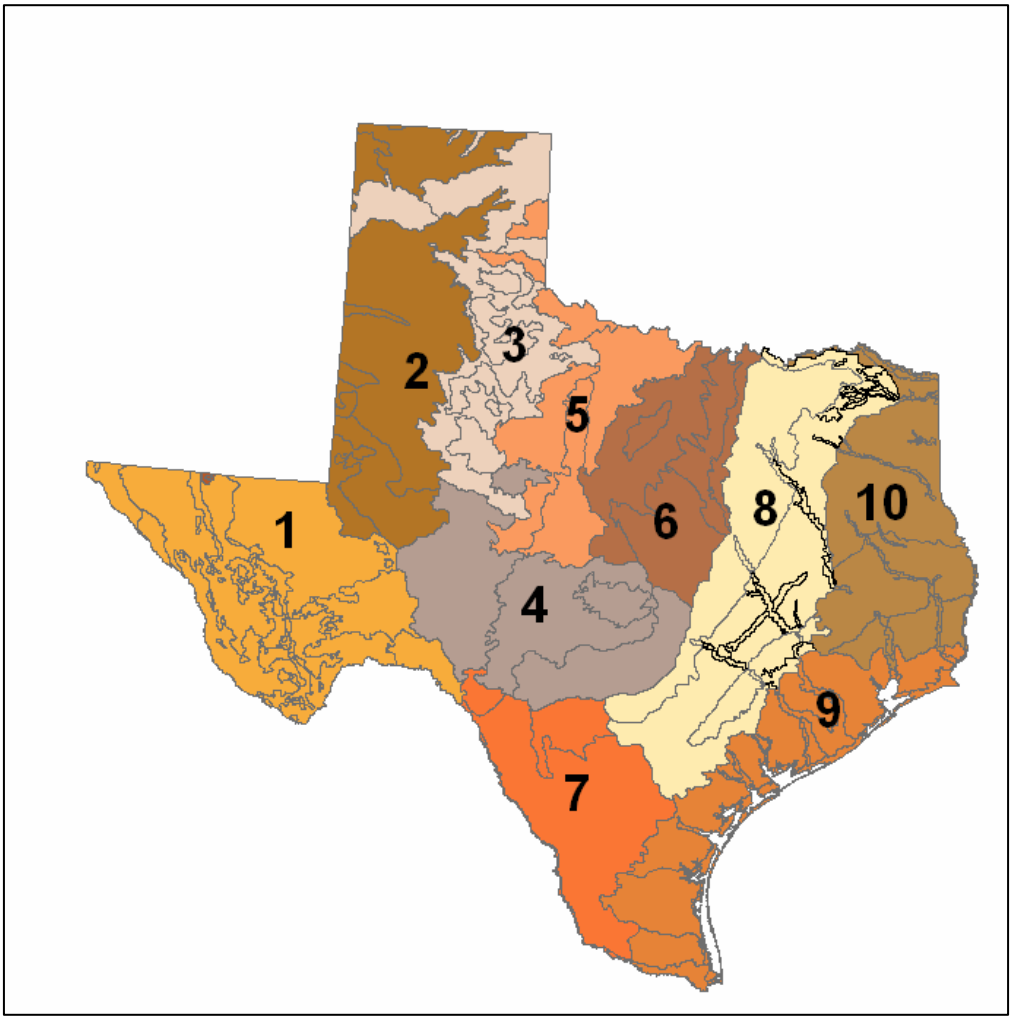

Fig. 2.1--Ecoregions of Texas. 1) Chihuahuan Deserts 2) High Plains 3) Southwestern Tablelands 4) Edwards Plateau 5) Central Great Plains 6) Cross Timbers 7) Southern Texas Plains 8) Post Oak Savannah and Blackland Prairies 9) Coastal Plain 10) Piney Woods (adapted from Omerink 1987).

have been established throughout the state. Records for many colonies had breeding bird data but lacked location coordinates and were therefore unusable.

Colonies were categorized into 5 types: flooded trees and shrubs, freshwater island, coastal island, upland, and unknown. These types are summarized and reported by ecoregion. A shapefile reflecting these coordinates was produced in ArcGIS 9.1 which was used for all geographic operations unless specified otherwise.

A 30m resolution land use raster set, National Land Cover Database (NLCD) 2001 zone 37b, was obtained from the United States Geological Survey (U. S. Geological Survey 2001). This data layer classifies land into 25 land class types and is in the Albers conical equal area projection (Table 2.1) (Homer et al. 2004).

A vector layer of major rivers and streams of Texas was obtained from the Texas General Land Office (2000) projected in NAD 1927.

Rationale for Model Parameter Selection

The spatial area for an evaluation of land use surrounding colonies was determined by bounding the geographic locations of all upland heronries in a shapefile using the minimum convex polygon function of Hawth's analysis tools, then buffering it 10,000m (Fig. 2.2). A geographic outlier from the Central Great Plains ecoregion was excluded. Upland colony locations collected in 2005 and 2006 of sites established after 2000 were used with NLCD 2001 to evaluate land use surrounding colonies (n =7). These locations were used because they were collected by the author using GPS and therefore are of known accuracy. Land uses surrounding these sites were compared with 60 random points within the analysis area. Random points were generated using the

Table 2.1--Land use classes of the National Land Cover Database 2001 (U.S. Geological Survey 2001).

Unclassified	Palustrine scrub/shrub wetland
High intensity developed	Palustrine emergent wetland
Medium intensity developed	Estuarine forested wetland
Low intensity developed	Estuarine scrub/shrub wetland
Open spaces developed	Estuarine emergent wetland
Cultivated land	Unconsolidated shore
Pasture/hay	Bare land
Grassland	Water
Deciduous forest	Palustrine aquatic bed
Evergreen forest	Estuarine aquatic bed
Mixed forest	Tundra
Shrub/scrub	Snow/ice
Palustrine forested wetland	

generate random points function in Hawth's analysis tools. Colonies and random points were buffered at distances ranging from 25 to 20,0000m to evaluate scale effects on land use types surrounding colonies. By inspecting these graphs no obvious patterns of importance by similar land use classes was detected. Therefore, similar land use classes were reclassified into 10 classes; forest, open water, wetland, residential, developed open space, pasture, shrub, and grassland (see Fig. 2.3-2.6). Urban, barren, tundra and snow/ice were removed due to their lack of perceived importance or pattern. From this preliminary evaluation, an extensive literature search, and personal observation, factors and their scales thought to drive the establishment of residential heronries were chosen.

Figures 2.3-2.6 suggest fine scale factors are more influential than course scale factors regarding upland colony site selection by herons and egrets. Percent cover of

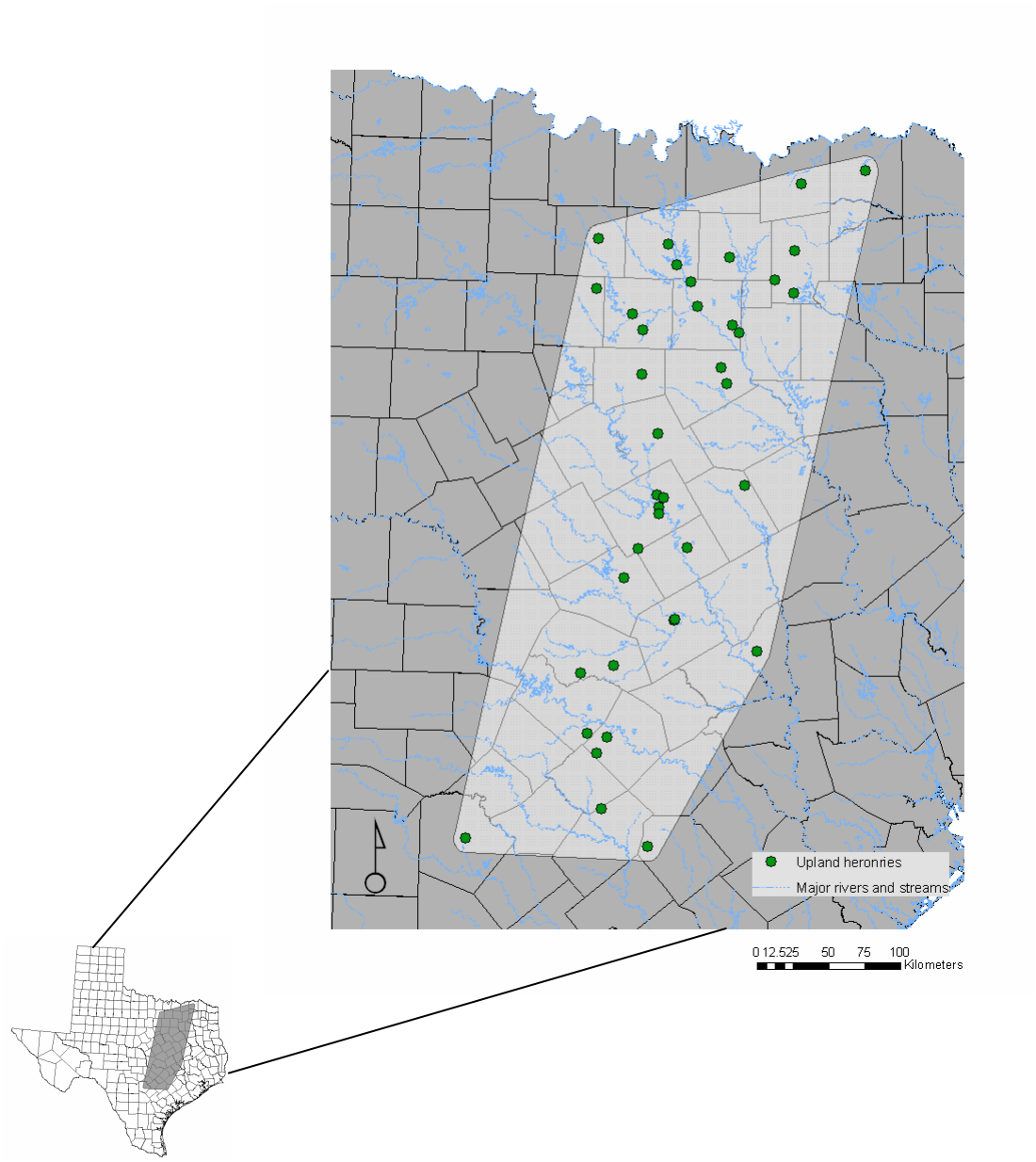

Fig. 2.2--Minimum convex polygon of all upland heronries with geographic location records in Texas.

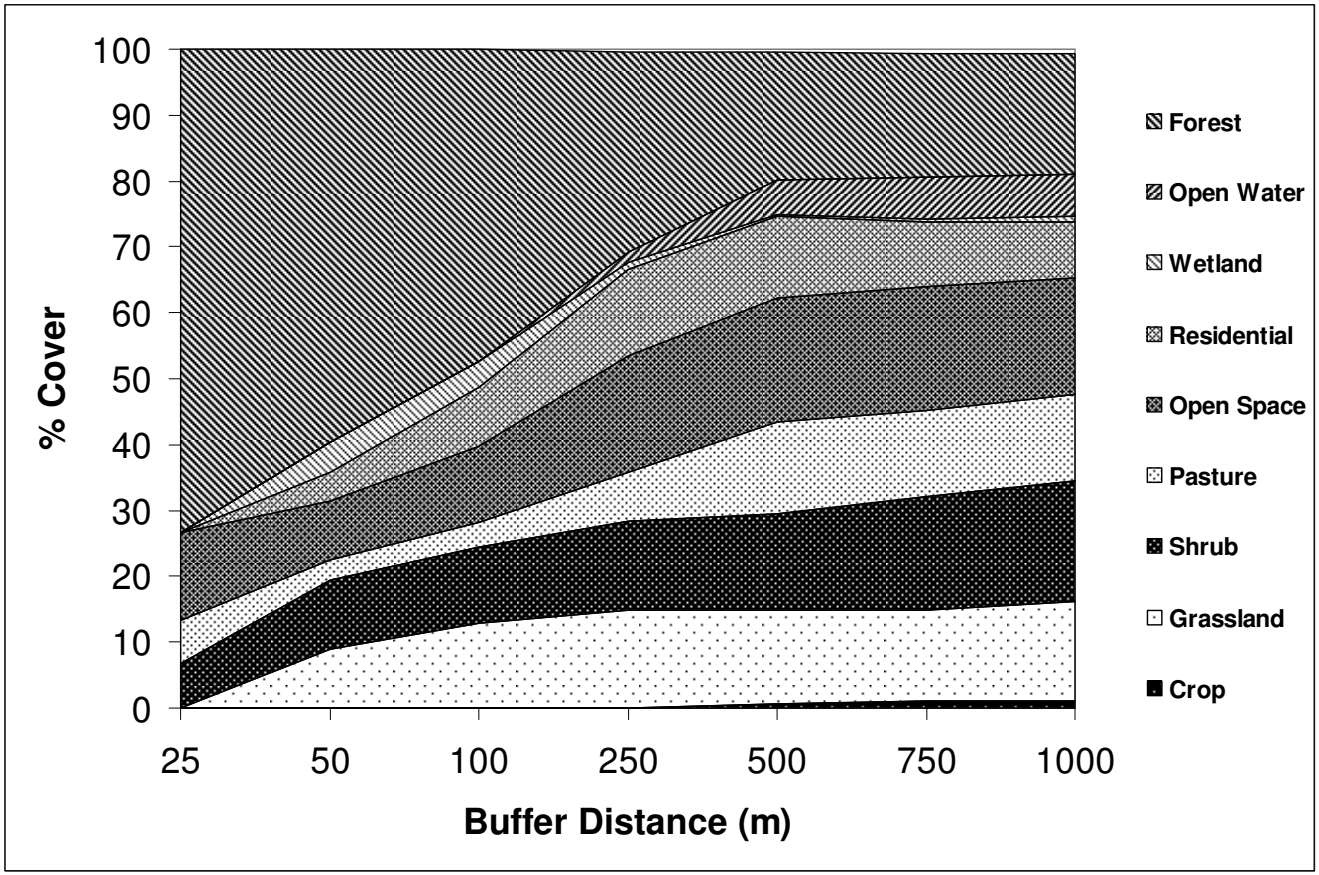

Fig. 2.3--Fine scale percent land cover by class at various buffer distances surrounding 7 upland heronry site locations collected in Central Texas.

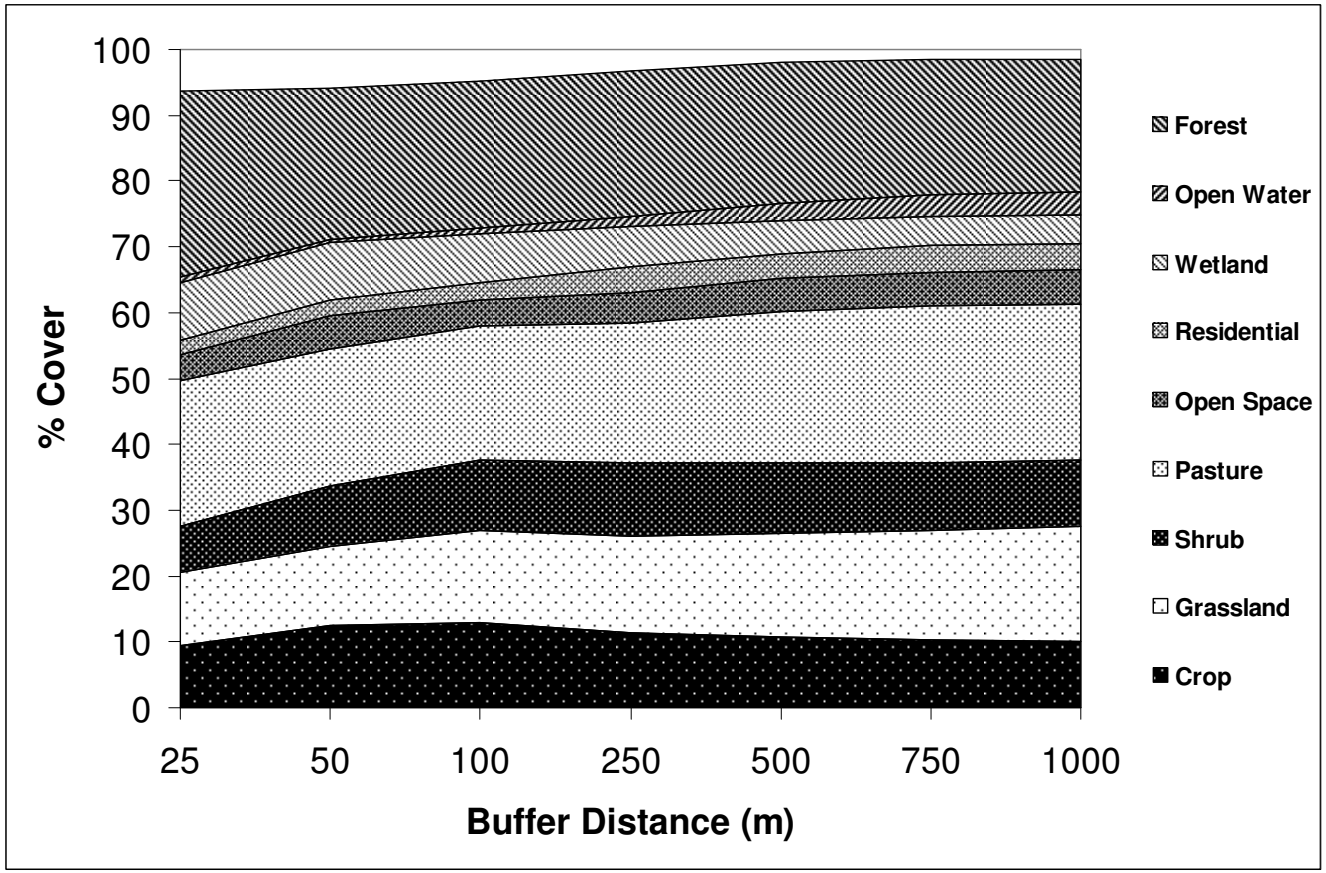

Fig. 2.4--Fine scale percent land cover by class surrounding 60 random points of a bounded analysis area in Central Texas at various buffer distances.

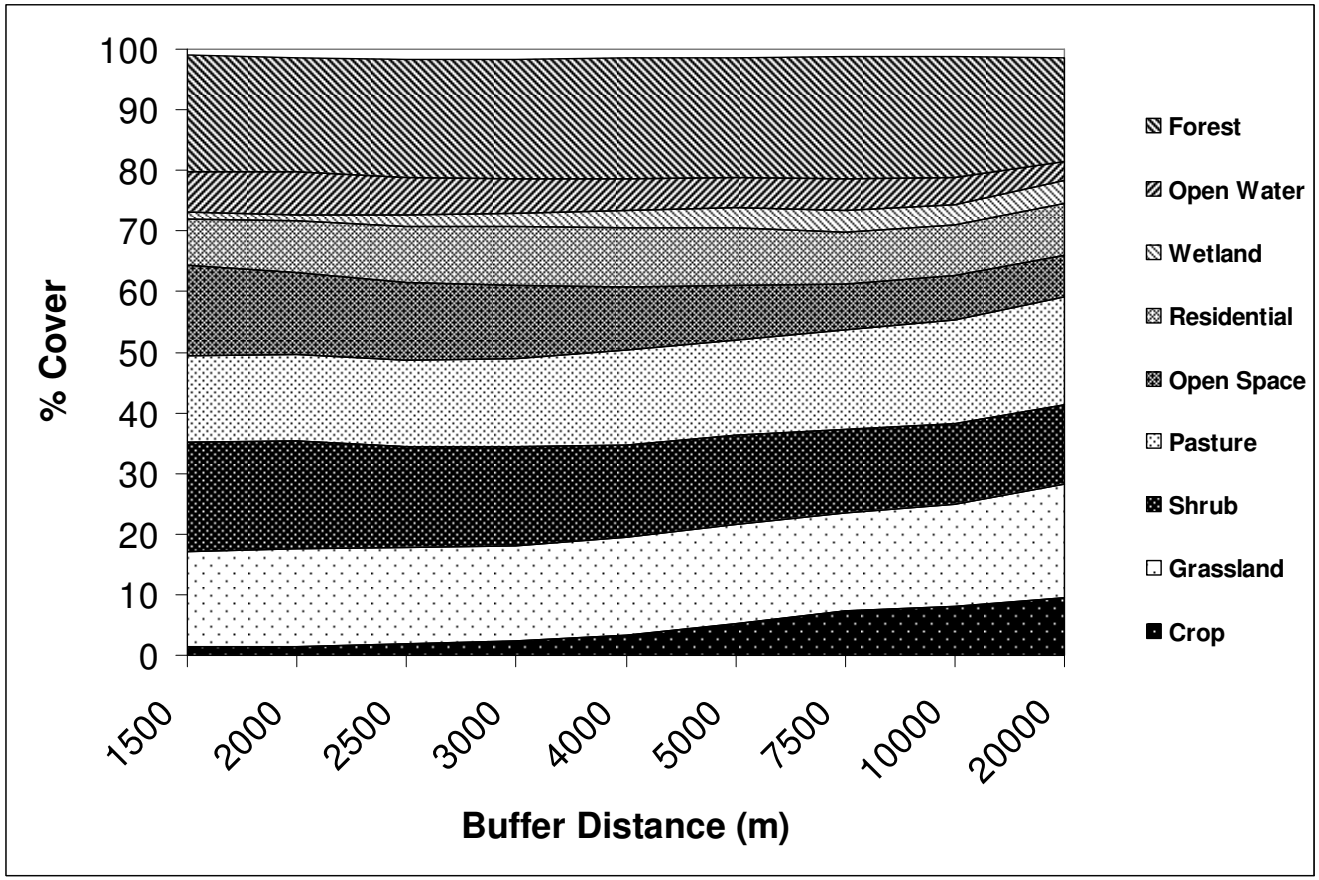

Fig. 2.5--Course scale percent land cover by class at various buffer distances surrounding 7 upland heronry site locations collected in Central Texas.

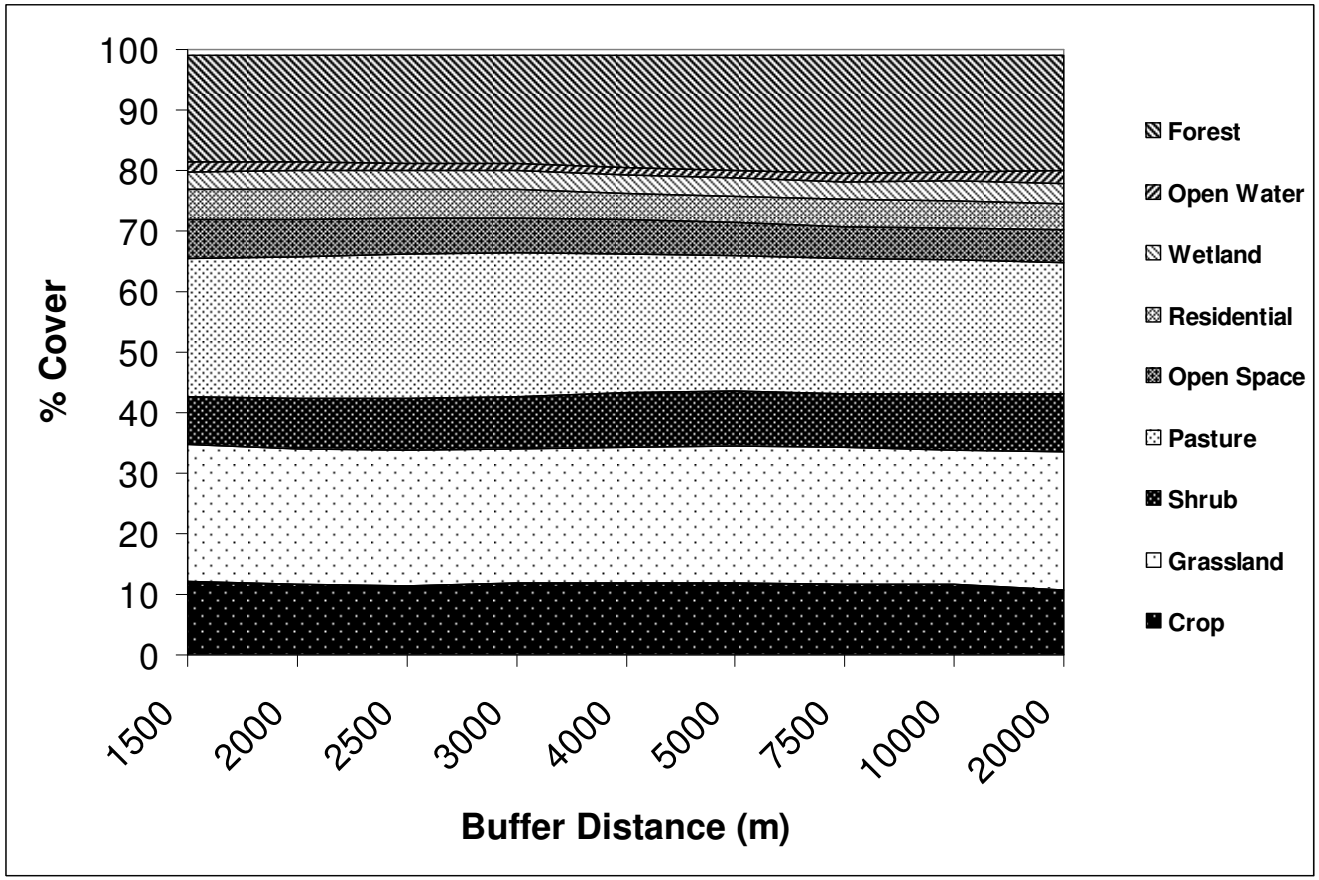

Fig. 2.6--Course scale percent land cover by class at various buffer distances surrounding 60 random points within the study area Central Texas.

most land use classes stabilize between 500 and 750 m from colony sites. This is likely a reflection of the size of most upland heronries, which are usually 0.5 to several hectares in area (Telfair 1979; M. L. Parkes unpubl. data). Fine scale land use classes which were disproportionately higher compared to land use classes surrounding random points included open water, forest, developed open space, and residential while there were less crop, pasture, and grassland. Interestingly, there was more wetland at very fine scales surrounding random sites than colony sites.

Proximity to water has been established as an important factor in the formation of all heron and egret colony types, including upland colonies (Dusi and Dusi 1968; Ogden et al. 1980; Bancroft et al. 1988; Dusi 2001; Bryan et al. 2003; pers. observ.). Normally upland colonies are within site of water or have small scale water adjacent to the nesting substrate (Dusi et al. 1971; Telfair 1983; pers. observ.). Edge of water classes was chosen because it seems particularly important for both nesting and feeding, as flooded substrate or foraging do not occur in deep water.

Upland colonies occur mainly in trees, and often these patches are fragmented, not large contiguous tracts of forest (pers. observ.). Frequently these upland sites are at the interface of roads or railroad tracks and forest patches, on the edges of towns of all sizes (Ray Telfair, pers. comm.; Linda Tschirhart-Heil, USDA, pers. comm.; pers. observ.). For these reasons forest edge and developed edge were included in the model.

Model Framework

The geographical extent of the habitat capability model was the area of known upland colony locations established after 1996, buffered by 10,000m (n = 14). The

extent of the colony distribution of these years was chosen to be comparable with the 2001 NLCD (U. S. Geological Survey 2001) (Figure 2.7).

Raster layers of each edge type were produced by reclassifying the full raster layer. Open water, woody wetlands, and emergent wetlands were combined into a water only layer. All forest types were combined into a forest only layer. Urban, residential, and developed open space were combined into a developed classes layer. Each raster layer was aggregated to 90 m resolution.

Each of these raster layers was imported into a program designed to calculate landscape shape metrics, Fragstats (McGarigal and Marks 1995). Fragstats produced a raster layer of total edge for each landscape class using a moving window that calculates the total amount of edge within the radius of a window for each cell. The radius of the window was 180 m (2 cells) for water and forest and 270 m (3 cells) for the developed classes. These radii were chosen because of the cell size and the patterns of buffer distance reflected in Fig. 2.3.

Resulting raster layers were imported back into ArcGIS to construct a habitat suitability model. Resolution was increased to 270m using the aggregate tool. Because upland heronries are about $100m^2$, a 270 m resolution was chosen to ensure each cell encompassed the phenomenon being modeled. A neighborhood sum operation was performed on the water edge raster layer in the shape of an annulus, with an inner radius of 1 cell and an outer radius of 2 cells. This operation uses a moving window in the shape of a doughnut to aggregate the parameter surrounding an inner radius. The result was a raster of the amount of water edge 540 m from each cell, but didn't include the

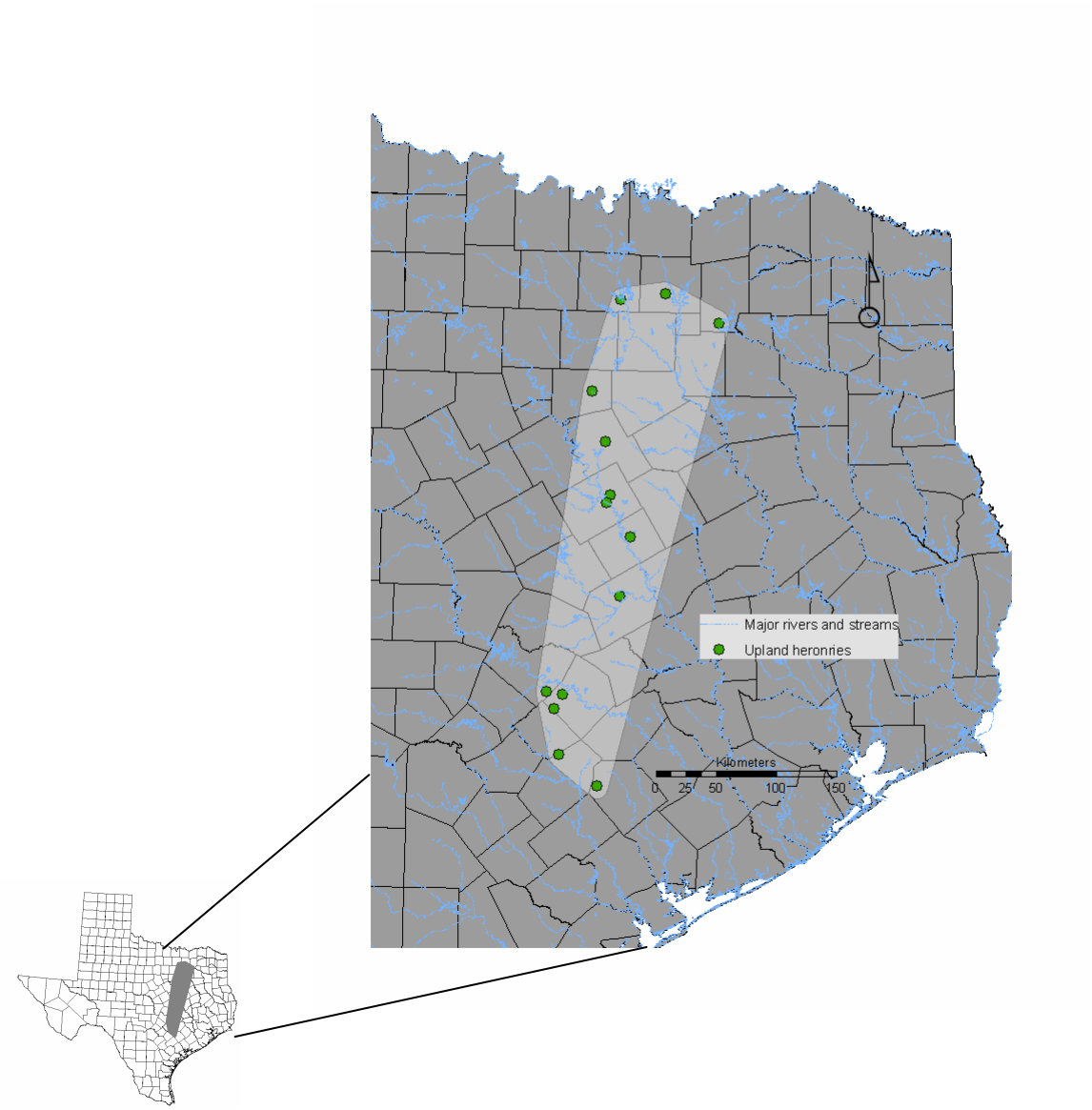

Fig. 2.7--Minimum convex polygon of all upland heronries with geographic location records in Texas, 1996-2006.

cell itself. This procedure was necessary because upland colonies by definition are not in water, but often have water nearby.

Each cell of each raster type was assigned a value of 0, 1, or 2. Cells containing no edge were assigned 0, and excluded from the subsequent classification. The remaining data for each raster layer was split into 3 classes using natural breaks. The lower class was assigned a 1 and the upper classes a 2.

The 3 classified total edge raster layers were combined using the sum function. The resulting raster contained cells with values between 0 and 6. Each value was assigned a corresponding suitability level (Table 2.2). Due to the small number of location records for upland colonies between 1996 and 2006, differences between the ratio of colony location habitat suitability classifications and the overall raster composition were tested using Fisher's exact test ($\alpha = 0.05$).

Results

A total of 232 colonies active between 1973 and 2006, containing a minimum of 100 breeding pairs of cattle egrets in at least 1 year, with geographic coordinates were found. Of these, 132 were in flooded timber, 29 were on coastal islands, 9 were on freshwater islands, 41 were considered upland, and 13 records did not contain enough information for colony type to be ascertained confidently (Fig. 2.7). Seventy eight percent of all non-coastal island colonies were within 5000 m of a major stream or river.

Sixty two percent of colonies were located either in the Piney Woods or Coastal Plain ecoregions, but no records of upland colonies were discovered for those areas

Table 2.2--Model raster values and their corresponding upland colony site predicted suitability level.

Model raster value	Colony site suitability
0	Very low
1 or 2	Low
3	Medium
4 or 5	High
6	Very high

(Table 2.3). The extent of upland colonies containing significant cattle egret breeding was restricted to Central Texas. Forty nine percent of the colony records in the Blackland Prairie and Post Oak Savannah ecoregions and 88% of the colony records for the Cross Timbers ecoregion were upland colonies.

Three edge raster layers were produced, with each cell assigned a value of 0, 1, or 2 (Fig. 2.8-2.10). The habitat suitability model consists of the sum of these raster layers (Fig. 2.11). Eleven of 14 colonies (78.6%) were in habitat classified as very high or high capability of supporting upland cattle egret breeding sites, while only 1 colony was classified as very low or low capability (7.1%) (Table 2.4). The distribution of colonies in the predicted habitat classes was significantly different from the expected distribution based on composition of the model raster layer ($p = 0.036$).

Discussion

Records of upland cattle egret colony locations in Texas were restricted in geographic extent. They were only reported in the central part of the state, mostly in the Post Oak Savannah, Blackland Prairies, and Cross Timbers ecoregions, similar to previous reports (Telfair et al. 2000*b*). Records of colonies in East Texas and along the

Table 2.3--Colony types containing at least 100 breeding pairs of cattle egrets a minimum of one breeding season summarized by ecoregion.

Ecoregion	Flooded tree/shrub	Freshwater island	Coastal island	Upland	Unknown
Piney Woods	50	3	0	0	2
Coastal Plain	49	1	29	0	5
Blackland Prairies and Post Oak Savannah	30	3	0	33	5
Cross Timbers	1	0	0	7	0
Southern Texas Plains	1	1	0	0	1
Central Great Plains	1	1	0	1	0

Table 2.4--Proportion of habitat capability raster layer and number of colony occurrences in each of five predicted habitat categories.

Predicted habitat category	Proportion of total area of predicted habitat category	Expected # of colonies in predicted habitat category	Observed # of colonies in habitat category
Very low	0.083	1.2	0
Low	0.376	5.3	1
Medium	0.233	3.3	2
High	0.283	4.0	8
Very high	0.024	0.3	3

Texas coast were in flooded tree and shrub habitat or on islands. Very few records of colonies were found west of the Cross Timbers. This breeding range is similar to the accepted breeding range of the cattle egret (Telfair 1994).

Cattle egret colony type distribution seems to follow a pattern reflecting course scale rainfall (Fig. 2.12). As average rainfall decreases east to west and away from the

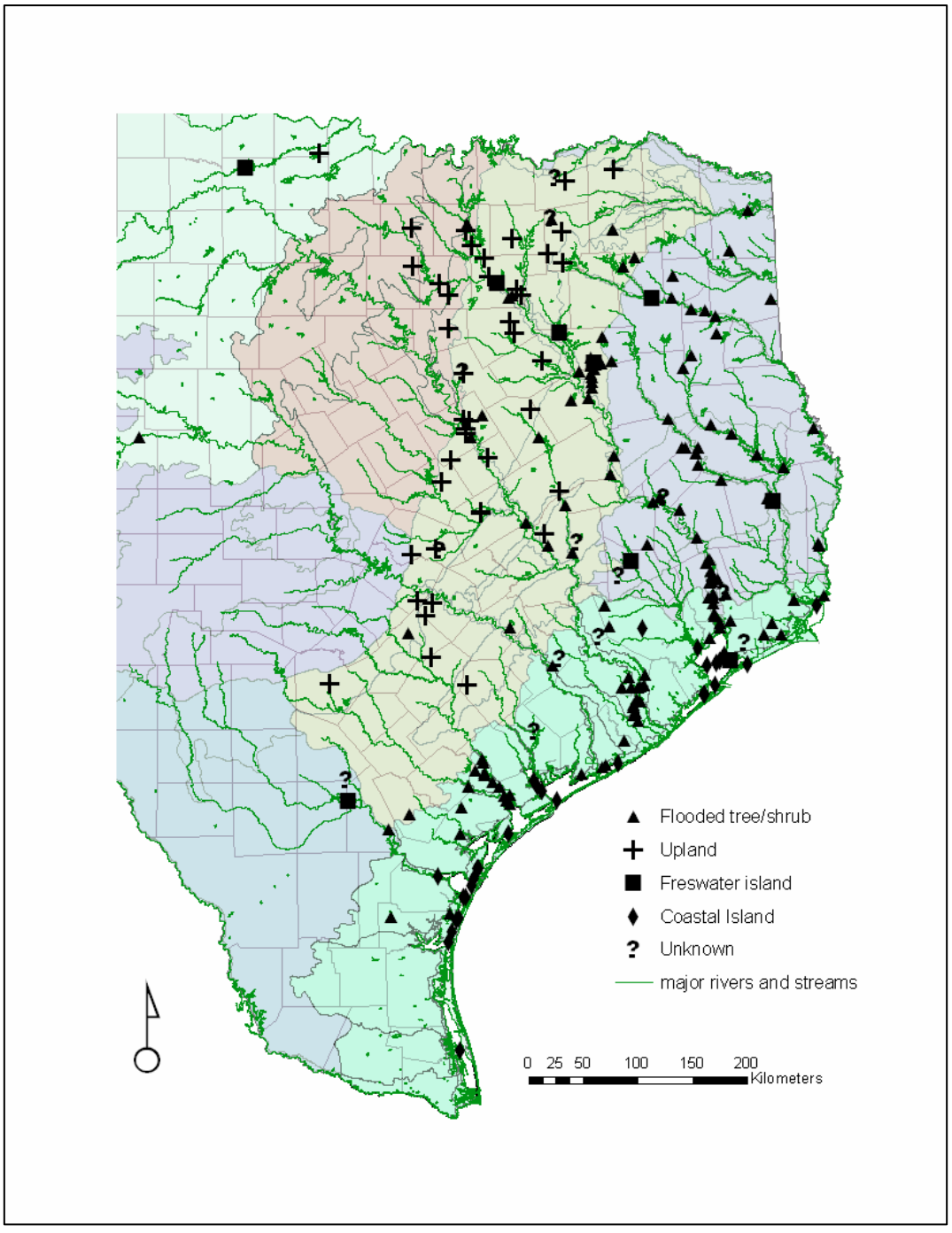

Fig. 2.8--Locations of cattle egret colonies with a minimum of 100 breeding pairs of cattle egrets during at least 1 breeding season categorized by colony type.

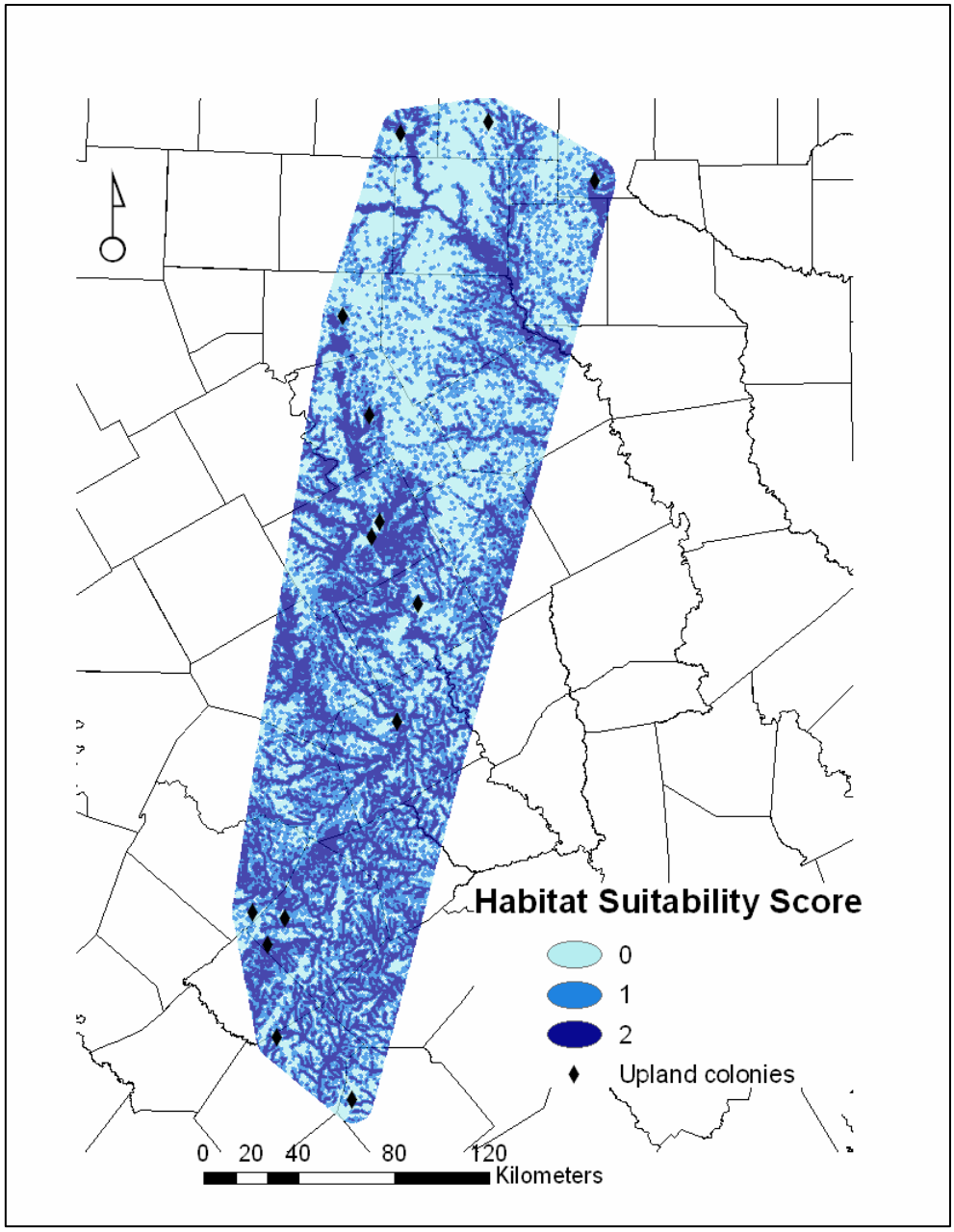

Fig.2.9--Raster layer of predicted habitat suitability due to aggregated water edge for upland cattle egret colony formation in Central Texas.

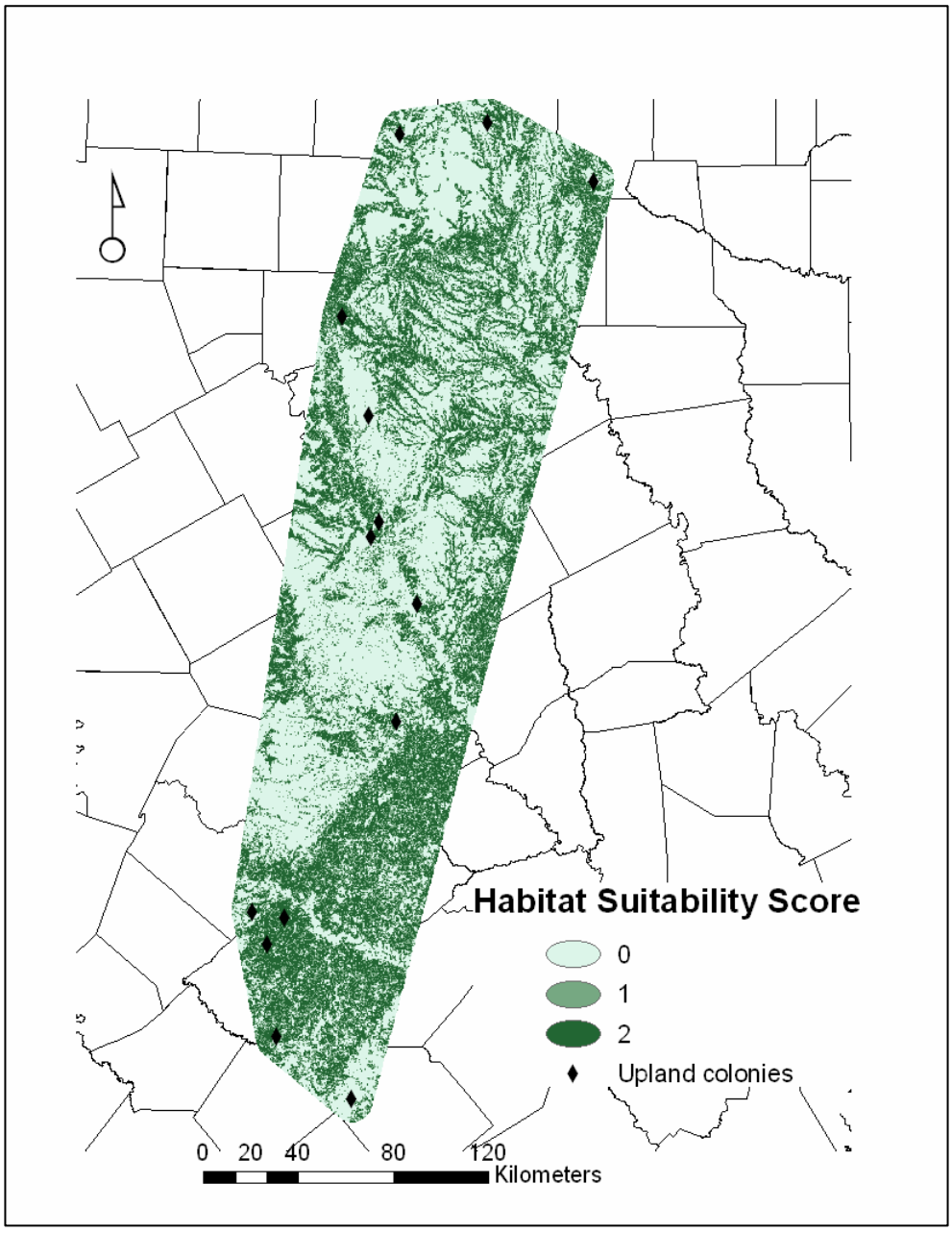

Fig. 2.10--Raster layer of predicted habitat suitability due to aggregated forest edge for upland cattle egret colony formation in Central Texas.

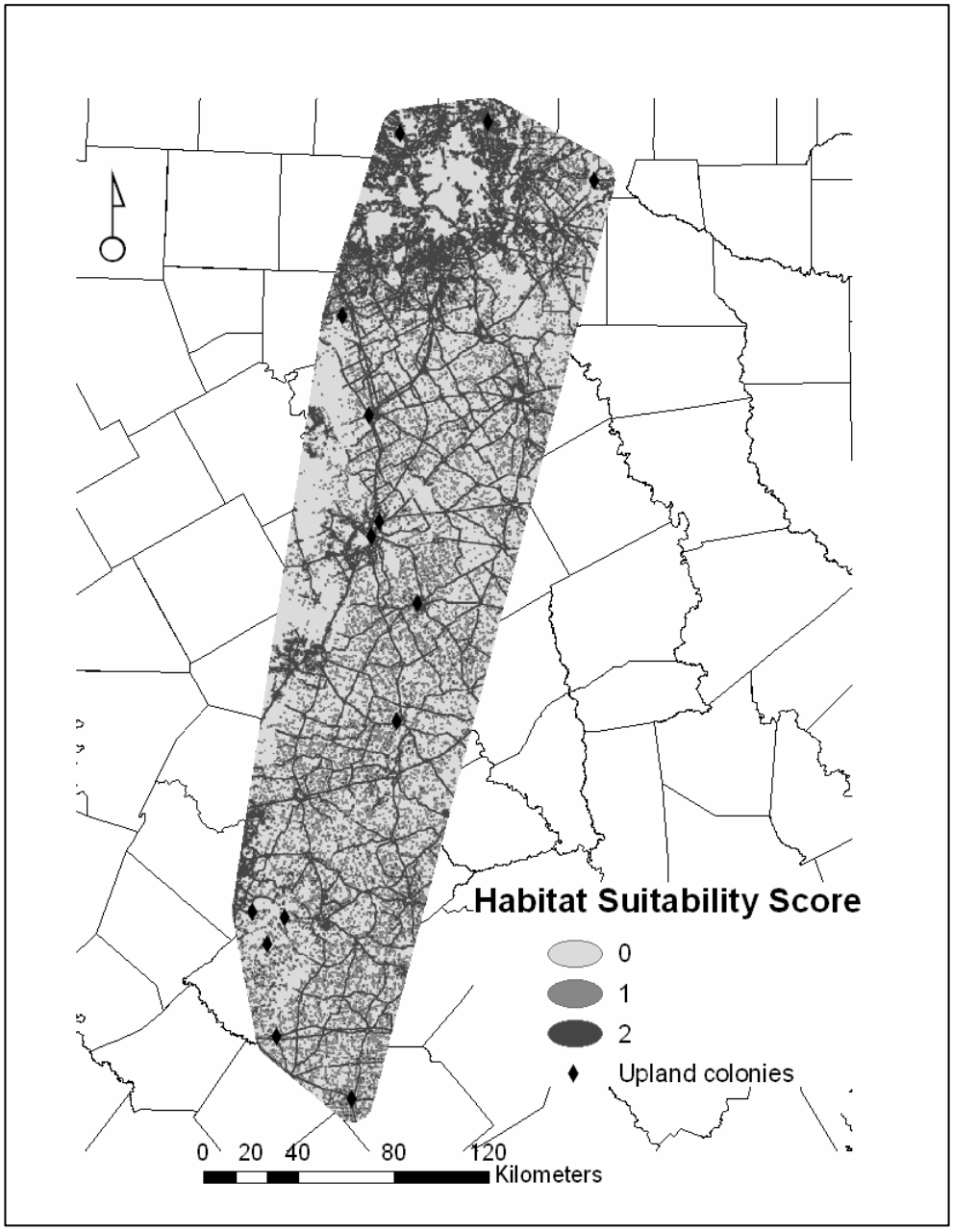

Fig. 2.11--Raster layer of predicted habitat suitability due to aggregated developed edge for upland cattle egret colony formation in Central Texas.

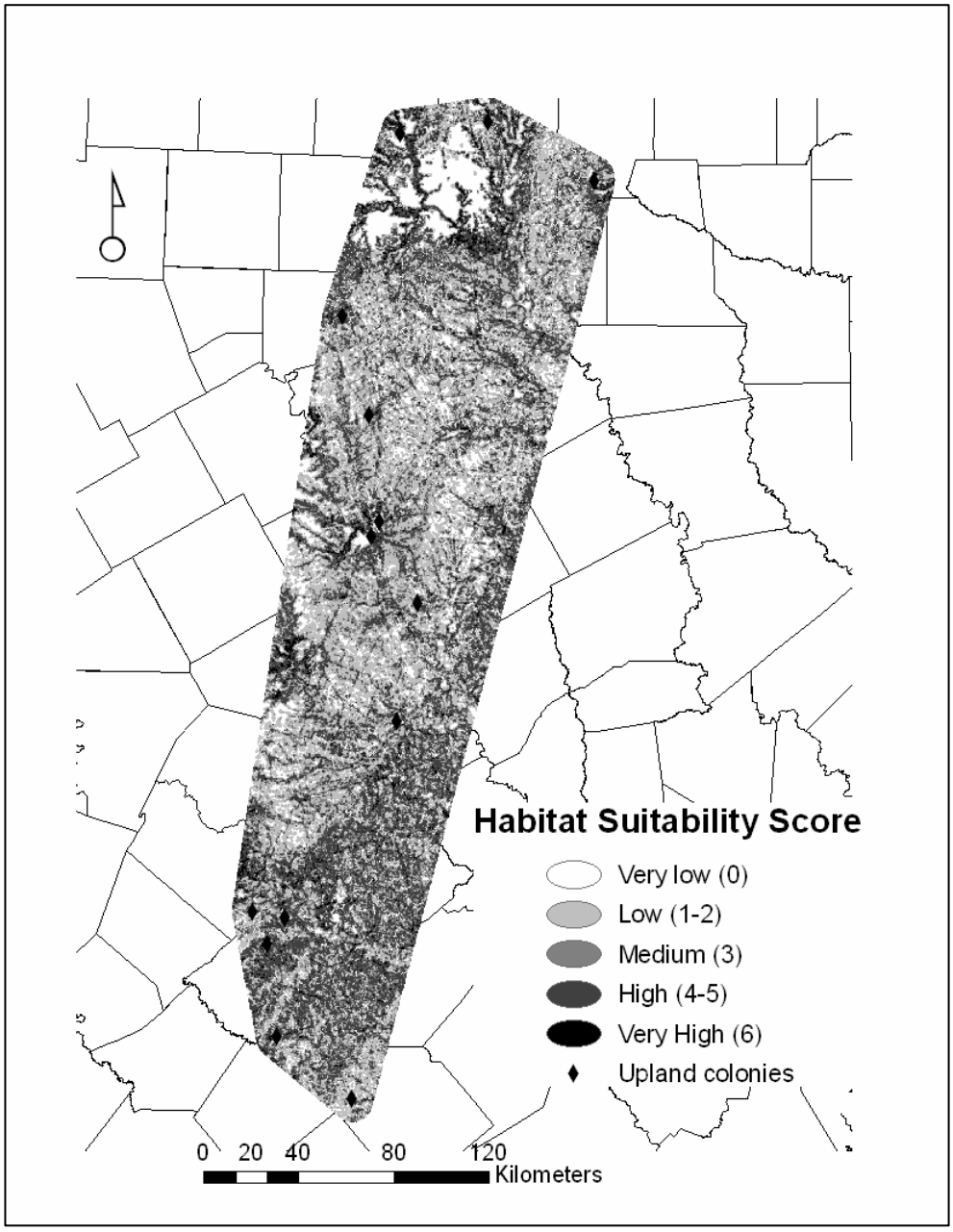

Fig. 2.12--Raster layer of predicted habitat suitability due to 3 classes of edge for upland cattle egret colony formation in Central Texas.

coast, more upland colonies appear as amount of aquatic land cover classes diminishes (Fig. 2.13). These observations suggest that large scale egret and heron nesting in upland habitat only occurs where there is sufficient availability of water resources for foraging and prey production, but preferred nesting habitat such as swamps and islands are limited.

In addition, large numbers of cattle egrets may be attracted to Central Texas for breeding due to the high density of cattle present there compared with other parts of the state (Figs. 2.14, 2.15, 2.16). Pasture and other agricultural land use classes were not present in large quantities surrounding colonies at fine scales and showed no trend at course scales (Fig. 2.3). The effect, if any, of agricultural land use on colony site selection is unknown.

The habitat suitability model suggests that upland colonies are more likely to form where edges of water, forest, and developed land occur in concert at relatively fine scales. Forest edges are used as nesting substrate.

Wading birds may be attracted to water for several reasons. Most wading bird species mainly rely on wetland habitats for feeding, although cattle egrets feed mainly on terrestrial prey (Kushlan and Hancock 2005). In Central Texas wading birds, including cattle egrets, are attracted to trees surrounding ponds or within ponds to roost (pers. observ.). Small scale water near trees may expand during locally heavy rains, mimicking flooded trees and shrubs potentially stimulating colony initiation.

The fact that colonies are likely to form on edges of development is more confounding. Most upland colonies are located along roads or railroad tracks and these

impervious surfaces may contribute to localized flooding. Human developments are typically established near water resources and provide additional, more reliable, water through irrigation and impoundment. These artificial enhancements may help alleviate potential hazards of drought and provide better foraging opportunities.

The main advantage in choosing flooded sites and islands for nesting is protection from reptilian and mammalian ground predators, especially raccoons (Dusi et al. 1971; Rodgers 1987; Frederick and Collopy 1989*b*). Raccoons are known to cause severe amounts of nest predation and trigger sudden colony abandonment (Pratt and Winkler 1985; Rodgers 1987; Post 1990). Edges of development may provide protection from predators when flooded timber or islands are absent. Prange et al. 2004 found that although raccoon densities were high in urban and suburban areas compared with rural habitats, their home ranges were smaller. Populations of raccoons in urban and suburban sites were aggregated around anthropogenic food resources which may reduce the need to search for and procure live food such as eggs, nestlings, and adult birds. In Central Texas domestic dogs often run loose on the edge of development, potentially deterring raccoons (pers. observ.). Population dynamics and foraging behavior of raccoons and other potential predators of herons and egrets in Central Texas along development gradients is unknown.

Studies on effects of urban gradients on nest predation and survivorship have produced conflicting results (Chace and Walsh 2004; Shochat et al. 2006). Some studies have found nest survivorship to be high in areas of intermediate disturbance, suggesting

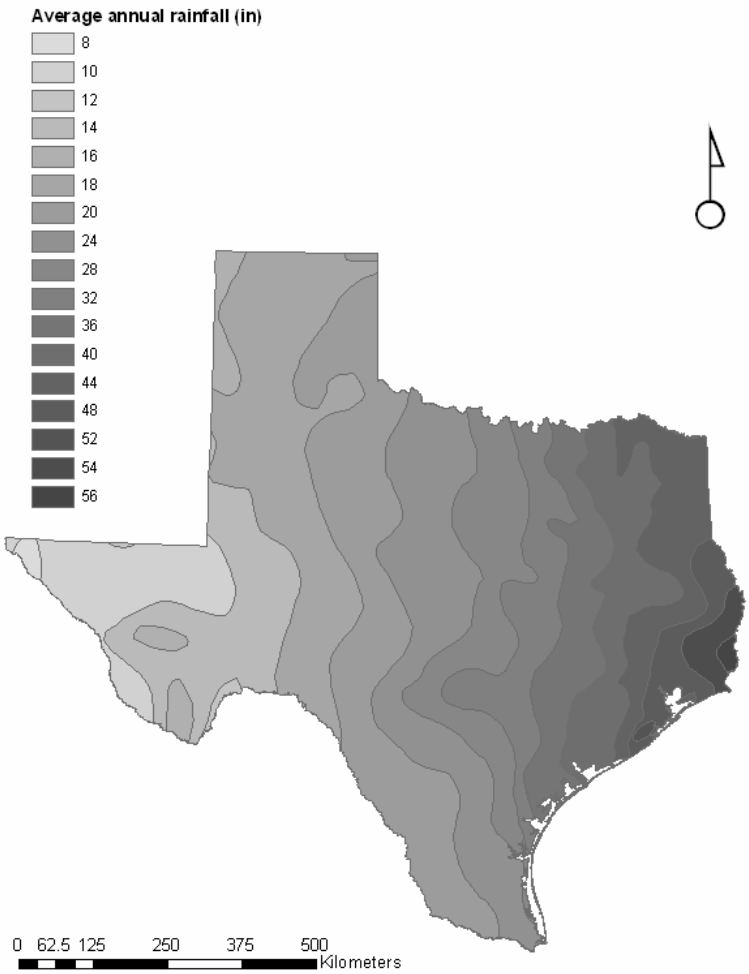

Fig. 2.13--Average annual rainfall in Texas.

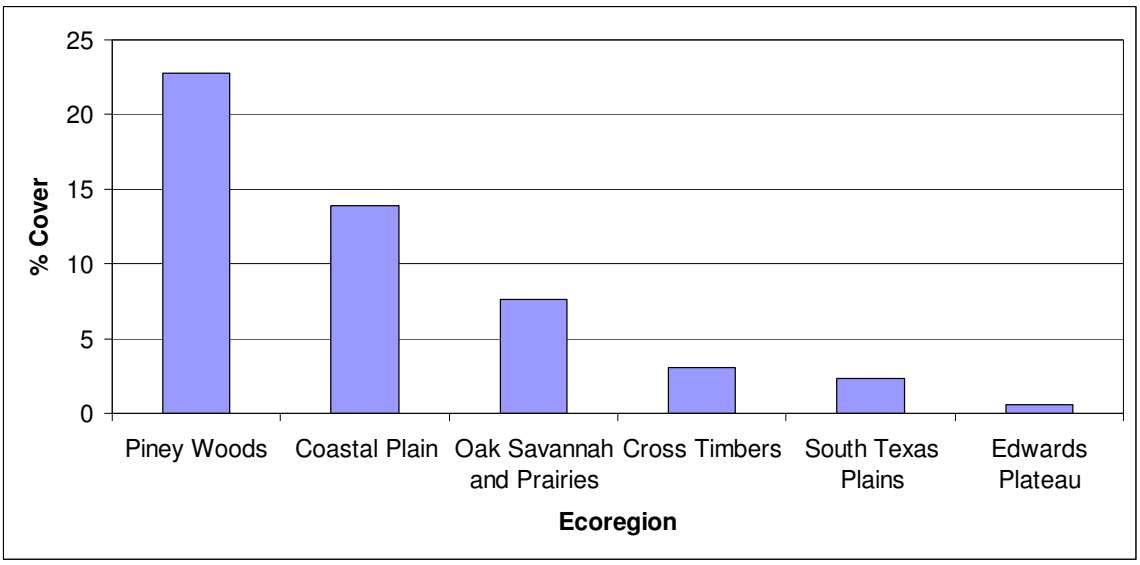

Fig. 2.14--Percent cover from the National Land Cover Database of open water and wetland land use classes combined for 6 ecoregions of Texas.

a non-linear relationship between predation and development (Fernandez-Juric et al. 1993; Blair 1996; Jokimaki 2000; Thorington and Bowman 2003). These intermediate areas have increased edge, ornamental plantings, and primary production than more developed areas dominated by impervious materials. Additionally, generalist species are thought to be favored in altered environments (Fraterrigo and Wiens 2005; Shochat et al. 2006). These relationships are likely specific to species, scale, and surrounding landscape matrix type (Orians and Wittenburger 1991; Dijak and Thompson 2000; Schmidt et al. 2001). More study is necessary to determine the exact mechanism or combination of mechanisms responsible for formation of cattle egret colonies along edges of development in Central Texas.

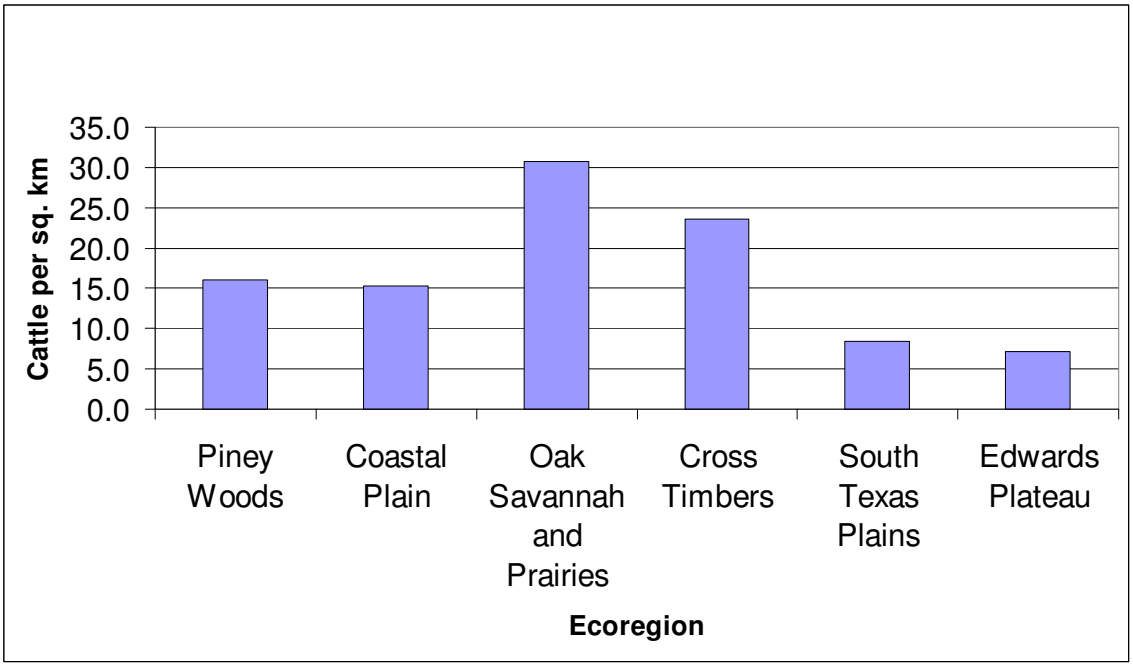

Fig. 2.15--Mean number of cattle per km^2 in 6 Texas ecoregions (Texas A&M Spatial Sciences Laboratory 2001).

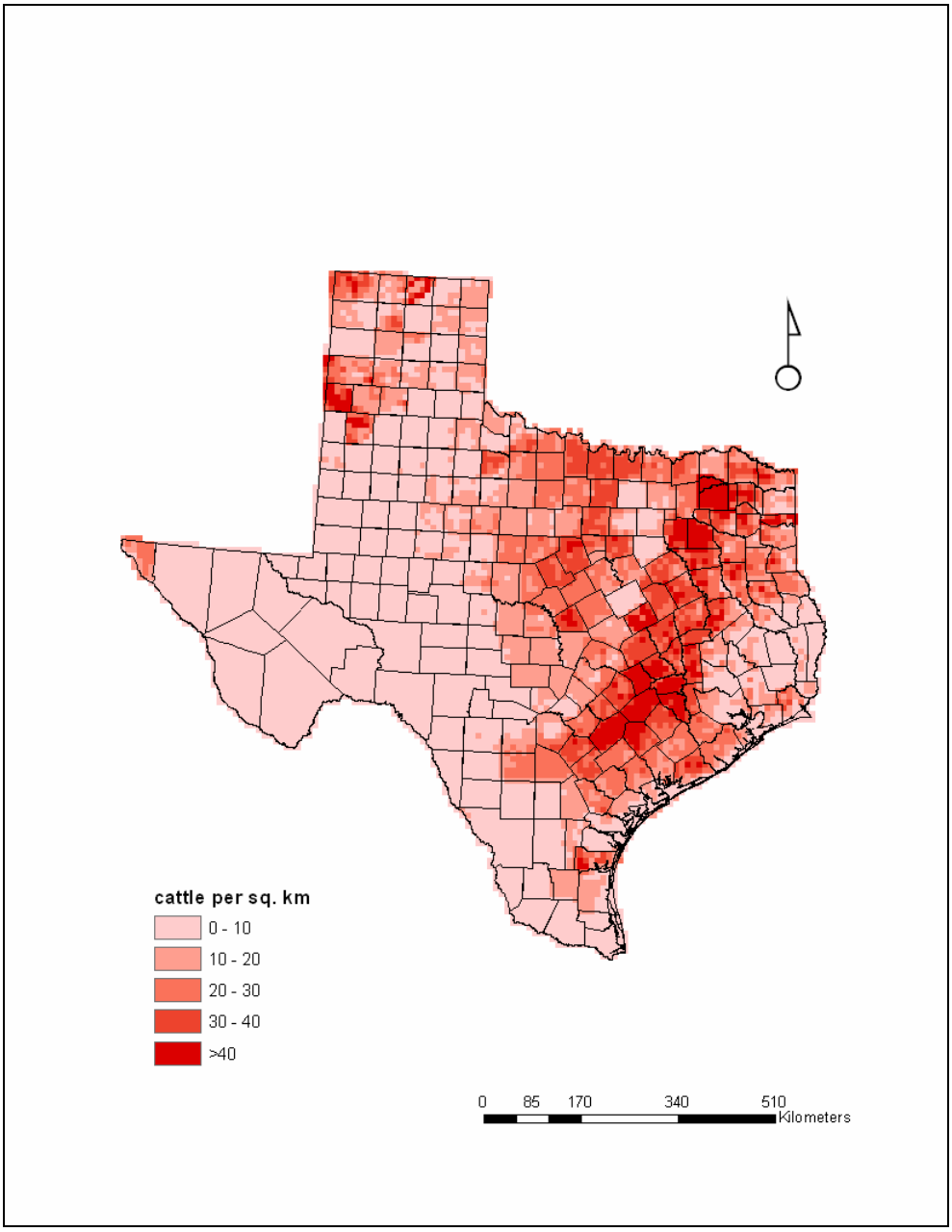

Fig 2.16--Cattle density per square kilometer in Texas (Texas A&M Spatial Sciences Laboratory 2001).

CHAPTER III

REPRODUCTIVE SUCCESS AND MANAGEMENT OF CATTLE EGRET COLONIES IN CENTRAL TEXAS, 2005-2006

Synopsis

Since the cattle egret established breeding populations in Central Texas in the early 1960's, upland residential mixed species heronries have been a nuisance in the region. Management of these heronries has mainly involved removing nesting vegetation or using noise to discourage reuse of nesting sites. Reproductive success parameters of 3 species of herons and egrets (cattle egret, little blue heron, and snowy egret) were colleted at various colony site types to evaluate if nesting in residential habitat conferred an adaptive advantage. In addition, management techniques were observed and evaluated. Focal nests were visited throughout breeding to collect nest survivorship and productivity data. Nineteen active colonies were found in or bordering the Post Oak Savannah and Blackland Prairie ecoregions of Central Texas during the breeding seasons of 2005 and 2006. Colonies were in residential, urban, island, and flooded tree and shrub habitat. Nests were found in 12 different tree and shrub species. Average number of nesting pairs of all 3 study species combined was 3139 ± 3659 per colony. Average seasonal nest survivorship for cattle egret colonies was 0.641 ± 0.168. Average nest fledging brood size was 2.19 ± 0.33 for cattle egret colonies. Residential colonies had more breeding pairs, greater nest survival, and were less productive than non-residential colonies on average, but these differences were not significant. Three colonies were not active in 2006 after wetlands they used dried due to drought. Colonies

where nest substrate was removed were not reused and no breeding was initiated nearby the next year. Propane cannons discouraged reuse of colony sites but only after prolonged application. Herons and egrets likely use residential sites when no flooded tree and shrub or island habitat is available. Providing the birds with preferred nesting habitat has not been attempted as a potential management strategy in Central Texas.

Introduction

Beginning with the first inland Texas cattle egret breeding record in 1961, cattle egrets have established large colonies in upland, residential areas of central Texas mixing with native species of herons and egrets (Telfair 1981*b*; Texas Colonial Waterbird Society 1982; Mora and Miller 1998; Telfair et al. 2000*b*). These colonies can contain thousands of nests, the majority usually are cattle egret, with little blue heron (*Egretta caerulea*) pairs, snowy egret pairs (*Egretta thula*), or both, always present (Telfair 1981*a*; Telfair et al. 2000*b*; pers. observ.). Other species, such as great egret (*Ardea alba*), black-crowned night-heron (*Nycticorax nycticorax*), anhinga (*Anhinga anhinga*) and additional species of wading birds nest at some sites. In Texas, large, residential heronries are mainly located within or bordering the Post Oak Savannah and Blackland Prairie ecoregions (Telfair et al. 2000*b*). Other residential heronries have been reported in Alabama, Oklahoma, New Mexico, California, and India (Dusi et al. 1971; Rao et al. 1996; Bill Howe, USFWS, pers. comm.; pers. observ.).

Some residential heronries are labeled a nuisance due to high densities of nesting birds producing noise and odor problems for human residents and guano damaging or destroying nesting trees and shrubs (Dusi 1977; Dusi 1979; Mora and Miller 1998;

Telfair et al. 2000*b*). Egrets and herons engage in facultative brood reduction (consistently, more eggs hatch than chicks fledge) via food provisioning and siblicide resulting in many dead chicks within these colonies (Mock et al. 1987; Voisin 1991). Presence of these dead chicks, occasional dead adults, thousands of live birds, and massive guano deposition, has led to public perception of colonies as a potential human health risk. There is no scientific evidence suggesting transmission of disease from heronries to humans.

Management of nuisance heronries has been difficult. Nesting herons and egrets are protected by the Federal Migratory Bird Treaty Act, as well as Texas state law, and harassment of nesting birds is illegal unless proper permits are secured (Telfair et al. 2000*b*). Most techniques employed in discouraging reuse of established heronries has involved disturbance of birds arriving at the heronry before nesting has initiated, or altering or removing nesting vegetation in the absence of breeding birds. Scare tactics such as noise, streamers, lights, smoke, spraying with water, balloons, and hawk silhouettes have been used (Dusi 1979; Telfair 1981*b*; Booth 1983; Telfair et al. 2000*b*). These tactics have been variable in preventing reestablishment of heronries and disturbed birds may establish new colonies in suitable sites nearby or recolonize sites in future years (Telfair 2000*b*). Management techniques have not been developed that adequately address concerns of residents, remedy nuisance problems without displacing them, treat birds humanely, and keep nesting vegetation intact. Lethal control has not been effective (Dusi 1979).

Why herons and egrets nest in residential areas of Central Texas is largely unknown. Prevailing theory focuses on the assumption that coloniality should evolve when its net benefits are greater than those of solitary nesting. Group factors thought to control formation of mixed-species heronries are predation and enhanced energy acquisition (Burger 1981; Forbes 1989; Kopachena 1991).

Although it is unknown if herons and egrets prefer residential breeding sites in Central Texas, repeated establishment of mixed-species heronries within residential areas suggests the net cost/benefit of residential nesting may be higher than nesting in non-residential areas (Orians and Wittenburger 1991). Measures of reproductive success integrate the range of breeding costs and benefits into a "common currency" useful in evaluating nesting habitat selection for colonial nesting species (Danchin et al. 1998). Higher nest survivorship at a site is likely due to localized factors such as predation, human disturbance, or severe weather, while nest productivity (number of offspring fledged) likely reflects the adequacy of food supply surrounding a site (Pratt and Winkler 1985; Mock et al. 1987; Frederick and Spaulding 1994; Telfair 1994; Smith and Collopy 1995; Frederick 2002; Vennesland and Butler 2004; Kelly et al. 2007).

The objective of this chapter is to evaluate whether there might be an adaptive reproductive advantage to nesting in residential habitats versus other habitat types in Central Texas. A higher nest survival rate or average fledging brood size or both at residential sites might indicate the presence of a natural selection benefit to individual nesters and provide inferences on the scale these benefits operate (Parnell et al. 1988; Hafner et al. 1993).

Study Area

During 2005 and 2006 locations of breeding cattle egrets were collected in the Post Oak Savannah and Blackland Prairie ecoregions of Texas. These two ecotypes intermingle in Central and North Central Texas, from the Texas-Oklahoma border south to San Antonio, encompassing a total area of approximately 8.1 million hectares (Fig. 3.1) (Gould 1975). The vegetation of the region is described as an ecotone between the eastern deciduous forest and tall grass prairie characterized by a forest mosaic of post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), water oak (*Quercus nigra*), winged elm (*Ulmus alata*), hackberry (*Celtis occidentalis*), yaupon (*Ilex vomitoria*) and mixed grass prairie. Today, nearly all the climax native mixed-grass prairie has been replaced by monocultures such as coastal Bermudagrass, dallisgrass, carpetgrass, and clover or converted to cropland (Schmidly 2002). The majority of the land is used primarily for ranching and farming but includes major river basins such as the Trinity, Brazos, and Colorado, major urban areas such as Dallas, San Antonio, and Austin, and towns and villages of all sizes.

Methods

An attempt was made to identify locations of all cattle egret breeding colonies within the study area during 2005 and 2006 by referencing historic records, networking with natural resource managers and birders, and following flocks of birds returning to night roosts. Search efforts began in mid-March when small herons and egrets normally start nesting in Texas (Telfair 1983). Colonies discovered early in nesting chronology (majority of birds in courtship or incubation) within 150 miles of College Station Texas,

were visited weekly to collect nest survivorship data. In 2006 these data were collected for some colonies further from College Station. Colonies too distant for weekly visits or discovered with most nests in later stages were visited sporadically to collect geographical and general nesting information.

Nests were observed from the ground using spotting scopes and binoculars. Active nests were counted and totaled by species where possible. At sites with large nesting populations or limited access, all observable nests were counted and total nesting pairs estimated by calculating nesting area using GPS and GIS, then extrapolating using observed or historical densities (Telfair 1983; Dusi and Dusi 1987; Post 1990). Nests were considered active if adults or young chicks were present on a nest platform.

Attempts were made to limit researcher disturbance while performing nest checks by monitoring from a distance, limiting research activity within colonies, and avoiding sudden movements. Researcher disturbance can greatly affect reproductive success of egrets and herons (Tremblay and Ellison 1979; Frederick and Collopy 1989*a*; Kopij 1997).

Roughly 100 cattle egret nests and as many little blue heron and snowy egret nests as possible were monitored weekly at each site. Focal nests were selected haphazardly from various vantage points surrounding the colony to introduce a degree of interspersion and limit observer disturbance. Complete randomization of focal nests considering project constraints was deemed impossible. Nests were labeled on

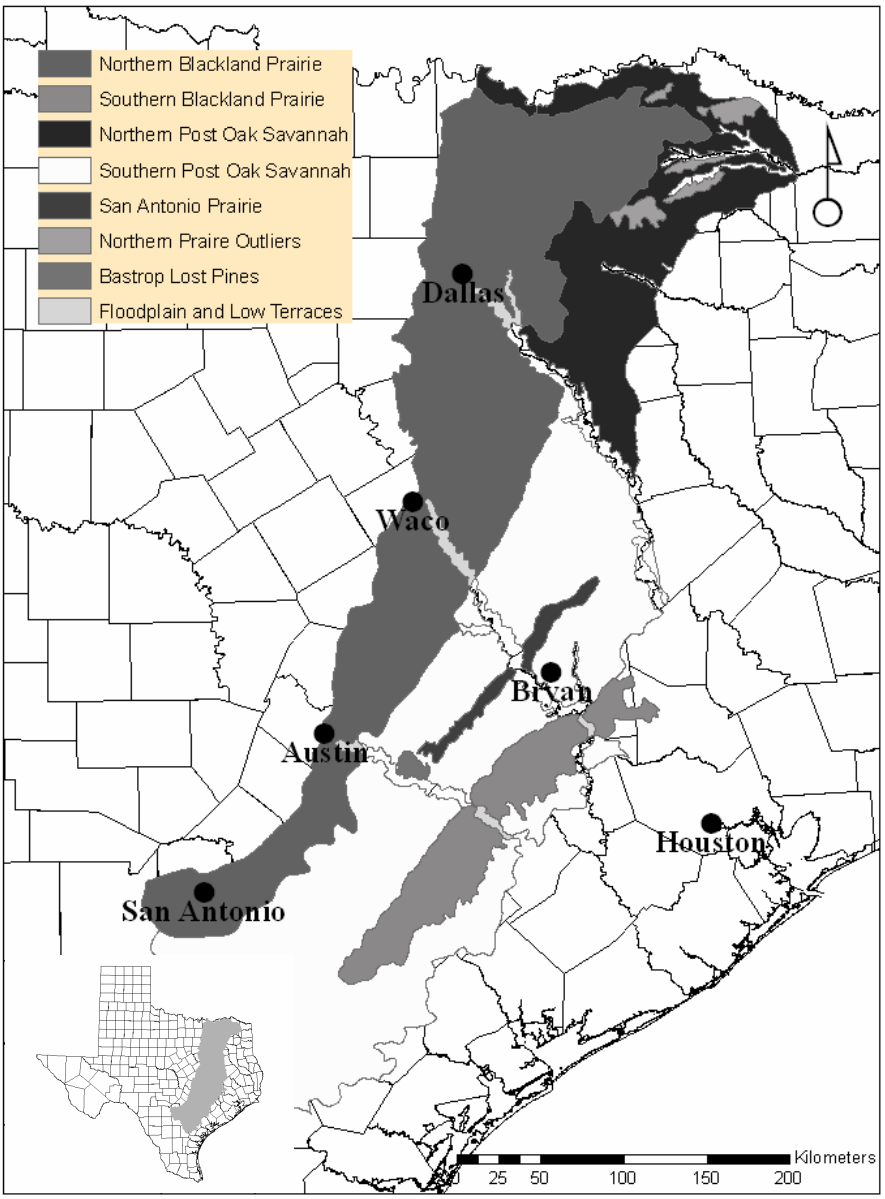

Fig. 3.1--Ecotypes of the Post Oak Savannah and Blackland Prairie ecoregions of Texas.

photographic printouts or sketches along with detailed written descriptions of nest location, effectively marking nests non-invasively (Pratt and Winkler 1985). In 2006, diameter at breast height (dbh) of nest substrate, nest height, and substrate species for residential and urban colonies and distance from shore for a single flooded tree and shrub colony were recorded. Dbh was measured with a dbh tape, nest height was measured post-breeding using a laser range finder, as was distance from shore.

Adult attendance, nesting stage (i.e., pair-bonded, incubating, small nestlings with adult, unattended nestlings, or fledglings) and brood size were determined for focal nests on each visit. Incidental behavior of adults (e.g., courtship displays, nest building, copulation, standing on nest, and chick feeding) were recorded. Clutch size was not determined for most nests to reduce researcher disturbance which might have been exacerbated by unattended eggs being exposed to extreme heat. Chicks were considered fledged from the nest 21days after hatching for cattle egret and little blue heron chicks and 14 days post-hatch for snowy egrets (St. Clair Raye and Burger 1979; Telfair 1994; Rodgers 1995; pers. observ.). After longer periods chicks become “branchers” and cannot reliably be assigned to a particular nest or dependably assigned a fate. Brood sizes at these nest ages are the nest fledging brood size as chicks can remain in or near colonies for longer periods (Frederick and Spaulding 1994). Nest age of the initial visit was approximated using known timing of breeding chronology, behavioral cues of adults, and chick development chronology (McVaugh 1972; McVaugh 1975; Telfair 1983). Most colonies were found before or near nest initiation, defined as the laying of the first egg, but this varied by colony.

Observations of potential predators and any evidence of predation was noted on each visit. Identification of predators using sign was attempted as outlined by Elbroch (2001).

Reproductive success was evaluated using Program MARK (White and Burnham 1999). This program calculates the maximum-likelihood estimate of daily nest survival (DSR) as outlined by Bart and Robson (1982) for nests visited at irregular intervals. The probability of nest survivorship is calculated daily, eliminating bias associated with timing of nest discovery and use of apparent nest survival estimates (Mayfield 1961, 1975; Dinsmore et al. 2002). The model requires a minimum of 5 pieces of information for each nest; 1) day nest was found; 2) day nest was last checked alive; 3) the last date the nest was checked; 4) nest fate; and 5) number of nests with that history (typically 1). MARK then generates an encounter history in live/dead format and estimates survivorship per day so if a nest fails between visits its survival probability can be estimated from the days it was observed alive and the length of the last interval. This method also estimates the variance of DSR enabling calculation of confidence intervals. Also, DSR can be estimated for groups of nests and Program MARK allows the evaluation of the effect of covariates on DSR using the logit or other link function.

DSR was generated for each colony, each year for cattle egrets. Due to small sample sizes, DSR was calculated for little blue herons and snowy egrets by combining nests across sites and years for each species. Cattle egret and little blue heron nest survivorship could be reliably estimated to 42 days after nest initiation while for snowy egrets this period was 35 days. Therefore DSR was raised to the power of 42 for cattle

egrets and little blue herons and 35 for snowy egrets to obtain seasonal nest survival rates (SSR) (Rotella 2005).

Precision of results are reported at ± standard deviation. Significant differences of reproductive parameters were evaluated using two tailed t-tests at α=0.05 (Ott and Longnecker 2001).

Field observations of nuisance heronry management and any reports to the USGS Brazos Field Station, Texas Parks and Wildlife Department, USDA, and USFWS were collected.

Results

Nineteen separate colonies were found within or just outside the study area in 2005 and 2006 combined, in 4 distinct habitat types. Eight colonies were discovered in thick trees and shrubs within 100 m of human, suburban type habitation, 7 in artificially flooded trees and shrubs, 2 on islands in reservoirs, and 2 in urban areas (see Fig. 3.2 for colony locations, see Appendix for colony site accounts). Urban colonies were considered a separate habitat type because they were not associated with residential areas and were located within major metropolitan areas, Dallas and San Antonio. Due to high levels of cattle egret activity and historical records, I suspect a large colony in the Trinity River Basin near Gus Engling Wildlife Management area went undiscovered. In addition, during 2005 there were multiple colonies in residential areas of Dallas but their locations are unknown (R. Stalbaum, USDA, pers. comm.). These colonies were disturbed with propane cannons and nesting ceased.

It is possible that additional colonies in the study area went undiscovered, especially in the far northern portion of the region which was less traveled and has little historic information concerning colony locations. I am confident that through networking and over 20,000 miles traveled by ground that the vast majority of large cattle egret colonies were located and most missed colonies were likely small or remote.

The average estimated date of nest initiation for cattle egret focal nests was May 29th (± 8.3 d) in 2005 (n = 435) and May 18th (± 10.5 d) in 2006 (n = 544). The earliest focal cattle egret nest initiation was May 11th and April 28th in 2005 and 2006 respectively. Average estimated nest initiation date for focal little blue heron nests was May 27th (± 12.5 d) in 2005 (n = 11) and May 15th (± 11.6 d) in 2006 (n = 27). Earliest initiation dates were May 10th and April 20th respectively. The average date of nest initiation for snowy egret focal nests was May 24th (± 8.5 d) in 2005 (n = 10) and May 14th (± 13.5 d) in 2006 (n = 30). Earliest snowy egret focal nest initiations were May 15th in 2005 and April 20th in 2006.

Nests were found in at least 12 different tree and shrub species; post oak (*Quercus stellata*), live oak (*Quercus virginiana*), yaupon (*Ilex sp.*), ash juniper (*Juniperus ashei*), eastern red cedar (*Juniperus virginiana*), mesquite (*Proposis glandulosa*), elm (*Ulmus sp.*), hackberry (*Celtis sp.*), chinaberry (*Melia azedarach*), mulberry (*Morus sp.*), black willow (*Salix nigra*), eastern cottonwood (*Populus deltoides*) and ash (*Fraxinus sp.*).

Average number of nesting pairs at each colony for the 3 study species combined was 3139 ± 3659 pairs for all colonies combined (n = 18), 4460 ± 4776 for residential

colonies (n = 7), 3105 ± 3088 pairs for flooded tree and shrub colonies (n = 7), 904 pairs for an island colony, and 880 ± 706 pairs for urban colonies (n = 3) (Table 3.1). For all non-residential (n = 11) colonies combined, average number of nesting pairs was 2298 ± 2660 pairs.

Sites monitored for nest survivorship were visited an average of 11.2 ± 3.1 times per season. An average of 81.8 ± 28.3 focal cattle egret nests were monitored weekly at each site per season. Estimated seasonal nest survivorship rate ($\overline{SSR}$) of all 984 focal cattle egret nests was 0.645 (0.613 to 0.676, 95% CI). Overall estimated cattle egret SSR for all colonies combined for both years (n = 12) was 0.664 ± 0.168. Four colonies were monitored in 2005 with an overall $\overline{SSR}$ of 0.641 ± 0.182. Two of these colonies were monitored again in 2006, in addition to six other sites. $\overline{SSR}$ was 0.678 ± 0.169 for cattle egrets across all sites (n = 8) in 2006.

Of these 12 estimates of SSR, 7 were in residential areas ($\overline{SSR}$ = 0.690 ± 0.182), 3 were in flooded trees and shrubs ($\overline{SSR}$ = 0.551 ± 0.185), one was in an urban area ($\overline{SSR}$ = 0.690) and one was on an island in a reservoir ($\overline{SSR}$ = 0.818). $\overline{SSR}$ for non-residential colonies combined was 0.632 ± 0.178.

At a small flooded tree and shrub colony monitored both years, nests less than 2 m from shore or on shore had a $\overline{SSR}$ of 0.314 (0.228 to 0.411, 95% CI) while those more that 2 m into the water had a $\overline{SSR}$ of .552 (0.500 to 0.653, 95% CI). The other flooded tree and shrub colony monitored had no nesting on shore and very limited researcher access.

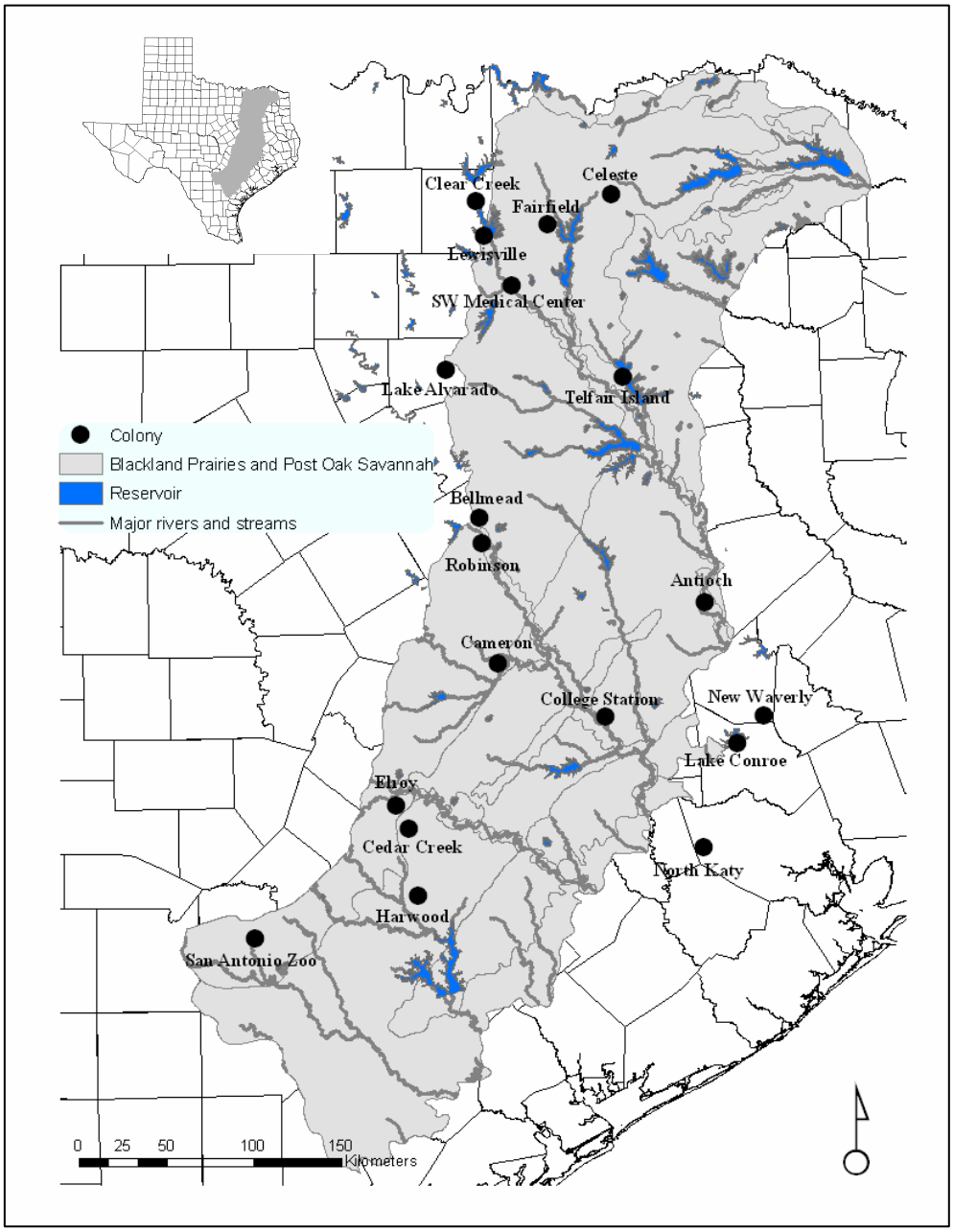

Fig. 3.2--Active large cattle egret colonies identified in the breeding seasons of 2005 and 2006.

Table 3.1--Summary of average number of nesting pairs of the 3 study species combined, seasonal survival rate of cattle egrets ($\overline{SSR}$), and annual nest fledging brood size ($\overline{nfbs}$) of cattle egrets by colony type (n = seasons of data).

Colony type	Avg. nesting pairs (n)	$\overline{SSR}$ (n)	$\overline{nfbs}$ (n)
All types combined	3139 ± 3659 (18)	0.641 ± 0.168 (12)	2.19 ± 0.33 (13)
Residential	4460 ± 4776 (7)	0.690 ± 0.182 (7)	2.11 ± 0.20 (7)
Non-residential combined	2298 ± 2660 (11)	0.632 ± 0.178 (5)	2.23 ± 0.45 (6)
Flooded vegetation	3105 ± 3088 (7)	0.551 ± 0.185 (3)	2.47 ± 0.40 (4)
Urban	880 ± 776 (3)	0.690 (1)	1.76 (1)
Island	904 (1)	0.818 (1)	2.09 (1)

Small sample size prevented SSR to be estimated by colony or year for little blue herons (n = 41) or snowy egrets (n = 40). $\overline{SSR}$ across all sites and years was 0.500 (0.349 to 0.653, 95% CI) for little blue herons (n = 41) and 0.632 (0.471 to 0.713, 95% CI) for snowy egrets (n = 40).

One residential colony, 5 flooded tree and shrub colonies, 1 urban colony, and 1 island colony were known to have been active during the study period and were not monitored for nest survivorship due to distance, access, or were discovered too late in the breeding season.

Average nest fledging brood sizes ($\overline{nfbs}$) for all successful focal cattle egret nests (n = 665) was 2.17 ± 0.75. Across the 12 sites $\overline{nfbs}$ was 2.19 ± 0.33. During 2005 $\overline{nfbs}$ was 2.29 ± 0.19 (n = 5) and in 2006 it was 2.13 ± 0.38 (n = 8). Residential sites had a $\overline{nfbs}$ of 2.11 ± 0.20 (n = 7), flooded tree and shrub sites a $\overline{nfbs}$ of 2.47 ± 0.40 (n =

4), for an island site $\overline{nfbs}$ was 2.09, and an urban site had a $\overline{nfbs}$ of 1.76. All non-residential sites combined had a $\overline{nfbs}$ of 2.23 ± 0.45 (n = 6).

$\overline{nfbs}$ was 2.27 ± 0.88 for successful little blue heron nests (n = 22) and 2.16 ± .864 for successful snowy egret nests (n = 26) across all sites and years.

Six colonies active in 2005 were inactive during 2006. Three flooded tree and shrub colonies were not used, presumably because water underneath the timber evaporated due to drought. An additional flooded tree and shrub colony site was not reused in 2006 because the nesting substrate was removed by the land owner. Similarly, nesting substrate was removed in the winter of 2005/2006 from a large residential colony site and nesting was not reinitiated nearby despite similar habitat. In another residential colony active in 2005 propane cannons were placed in the middle of the colony upon arrival of birds in 2006 and no nesting was observed at this site. A colony of similar breeding population was discovered approximately 10 miles away from the disturbed site.

In April and May 2005, weekly observations of propane cannons firing within an active 2004 colony site near Cameron Texas were made at dusk. Thousands of egrets and herons were attracted to the site nightly for over 1 month. Upon arrival they were disturbed by noise discharge, then circled the town and its vicinity before eventually landing in dense vegetation adjacent to a pond to roost. Large colonies had been located in Cameron for roughly 15 consecutive years, but no nesting was observed there in 2005 or 2006.

Two night roosts occupied by thousands of wading birds were found during the breeding season of 2005. Both roosts were on the edges of ponds containing no emergent vegetation. Despite the fact that roosting birds appeared to be in breeding condition (brightly colored soft parts), no colonies were found near these roosts.

Discussion

Colonies during this study were discovered in similar habitats and contained similar sized breeding populations as in previous surveys of the region (Telfair 1979, 1993). These habitats were flooded tree and shrub, islands in reservoirs, and trees and shrubs in upland urban and suburban areas. No colonies were found in upland trees and shrubs outside of residential or urban areas, in pastureland for instance, or on the shore of ponds unless accompanied by nesting in flooded timber.

Colonies in flooded trees and shrubs were artificially flooded. Landowners flooded portions of their property for recreational opportunities, like fishing, swimming, or for waterfowl habitat, or in one case, as the result of mining activities. These sites were colonized between 1 and 3 nesting seasons following their inundation. During 2005 and 2006 Central and North Texas experienced drought conditions and the entire study area was classified as in extreme or severe drought at the end of the 2006 breeding season (NOAA, unpublished data). Therefore little, if any flooded timber lands, such as oxbow lakes, were created naturally in this period.

Drought conditions apparently precipitated abandonment of 3 flooded tree and shrub colonies that became dry between the 2005 and 2006 nesting seasons. This, combined with low levels of nest survivorship on shore or within 2 m of shore at 1

flooded tree and shrub colony, the discovery of large roosts around ponds with birds in breeding condition, and no colonies discovered in trees and shrubs surrounding wetlands, suggest that these birds will not use wetland edges for nesting unless emergent substrate is colonized first. As reflected in many other studies of small herons and egrets in other regions, it seems likely that island and flooded tree and shrub sites are the preferred nesting habitat for these species but are limited and ephemeral in Central Texas (Bancroft et al. 1988; Rodgers 1995; Parsons and Master 2000). For unknown reasons sites near human habitation seem to be the alternative.

Little blue herons arrive first at many colonies and it is hypothesized that this species may select colony sites (Dusi and Dusi 1968; Telfair 1981*a*; Belzer and Lombardi 1989; pers. observ.). Little blue herons and snowy egrets mostly nest in mixed species colonies on isolated islands or in swamps throughout their range, suggesting predator avoidance and proximity to wetland feeding areas are of primary importance (Rodgers 1995; Parsons and Master 2000). The main advantage in choosing flooded sites and islands for nesting is protection from reptilian and mammalian ground predators, especially raccoons (Dusi et al. 1971; Rodgers 1987; Frederick and Collopy 1989*b*). Raccoons are known to cause severe amounts of nest predation and trigger sudden colony abandonment (Pratt and Winkler 1985; Rodgers 1987; Post 1990). Considering herons and egrets display no group colony defense behaviors (e.g. mobbing), nesting on isolated islands or flooded trees and shrubs seems to be their only antipredator defense strategy (Rodgers 1987). The most likely reason for choosing

residential sites as an alternative is avoidance of ground predators over other areas, though this hypothesis has not been specifically tested.

If in fact little blue herons and snowy egrets choose nesting sites used by cattle egrets then their reproductive success parameters might be most important when evaluating differences between nesting habitat types. Unfortunately, sample sizes were too small to evaluate these species on a site by site basis. Overall, the $\overline{SSR}$ of 0.500 for little blue herons was lower than reported by Frederick (1995) in the Florida Everglades, 0.728 and 0.716 for 2 years respectively. $\overline{SSR}$ of 0.632 for snowy egrets was more similar to rates reported by Frederick (1995) in Florida (0.712) and Kelly et al. (2007) in California (0.666).

For cattle egrets, residential colonies had on average larger population sizes, higher nest survivorship, and lower average nest fledging brood sizes than non-residential colonies, but these differences were not statistically significant. These lack of differences may be real or could be due to small sample size, the presence of outliers, or both. For both clutch and brood sizes, each pooled for 4 habitat types (the 3 types in this study plus coastal islands) in a larger region of Texas, Telfair (1993) found no significant differences. He found reproductive success and average fledging brood sizes to be higher than reported here, but this is likely due to differences in methodology (Telfair 1993; Telfair and Bister 2004). Mora and Miller (1998) reported very high nest success and similar fledging brood sizes at a residential colony in Bryan, Texas over 2 breeding seasons.

Nests in the center of large residential colonies were not monitored due to lack of visibility through dense vegetation and colonies were not regularly entered in order to limit researcher disturbance. At other site types nests from more representative portions of the colony were visible and could be viewed using remote observation protocol. Some studies suggest that nests near the center of colonies have higher survivorship; therefore non-random choice of focal nests may have biased results (Siegfried 1972; Dami et al. 2006; but see Ranglack et al. 1991).

Residential colonies had, on average, more breeding pairs than non-residential colonies, but not significantly. Two small residential colonies were initiated late in the breeding season of 2006 lowering the mean and increasing the variance of residential breeding population estimates. Colonies are often established with relatively few breeding pairs and increase in population at varying rates in subsequent years, especially if breeders are highly successful (Krebs et al. 1994; Danchin et al. 1998; Mora and Miller 1998; Kelly et al. 2007). In addition, colonies with large breeding populations are less likely to be abandoned than colonies with fewer breeding pairs (Kelly et al. 2007).

Nests in colonies of flooded trees and shrubs and on islands were observed to be very dense within available substrate. Birds in flooded tree and shrub sites nested first on substrate in water, then spread toward, and at 1 site, onto shore. On islands nesting attempts on bare ground were observed after nesting substrate seemed saturated. Ground nesting has been reported on other islands (Telfair and Bister 2004). Herons and egrets nesting on the ground is seemingly unreported for non-island habitats. These observations suggest flooded trees and shrubs and island habitat types are limited not

only in their presence, but also in area and amount of nest substrate contained within available sites (Telfair et al. 2000*a*). Nesting birds in residential colonies never filled their particular habitat patch during this study and these patches are likely unlimited. The phenomenon of nuisance heronries in Central Texas is likely rooted in the adaptability of cattle egrets to current land use patterns which provide ample foraging opportunities but a limited amount of preferred nesting habitat.

Observations of nuisance heronry management techniques reflected previous reports (Telfair et. al 2000*b*). Complete removal of vegetation eliminated nesting at a nuisance residential site and an unwanted flooded tree and shrub site. Nesting was not initiated nearby the residential site even though similar, adjacent substrate was not removed.

Loud noise emitted from propane cannons was effective in preventing reuse of colony sites without removing vegetation. Propane cannons can be set to discharge sporadically at intervals of 1 to several minutes. It was observed that this disturbance must be focused within the colony to prevent reuse and the amount of repetition needed to prevent recolonization was variable, from 3 days up to 6 weeks (Linda Tschirhart-Hejl, USDA, pers, comm.; pers. observ.). This disturbance may affect reproductive success by delaying nest initiation and may prevent some birds from nesting for 1 or more breeding seasons. At 1 site where noise was placed approximately 75 m from the colony edge birds would react by flying off their perch when the noise discharged, but quickly returned to nesting activities. Discharging noise adjacent to this colony may have limited the number of nesting pairs but did not discourage nesting overall.

Observations of birds returning to disturbed sites but not nesting in seemingly suitable adjacent or nearby substrate suggests that small herons and egrets become focused on previously occupied nesting sites and will not initiate nesting at an adjacent site unless prompted by some unknown combination of triggers. Observations of residential colony establishment are rare, so conditions at initial colonization are unknown.

Environmental factors triggering colony establishment are complex. In addition to a suitable nest site, a concentration of birds and foraging conditions in the vicinity of the colony likely to provide adequate food for adults and their young for the months long nesting period are needed (Ogden et al. 1980; Bancroft et al. 1994). These foraging conditions are variable by species. It has been suggested that the breeding distribution of little blue herons and snowy egrets is dependent upon the availability and distribution of crayfish (Telfair 1981*a*).

A potential trigger for initial colonization of these sites may be the presence of standing water beneath or very near nesting substrate. Wading birds were attracted to substrate bordering ponds or above standing water to roost. If courtship and nesting were initiated before the water receded, birds might elect to continue breeding there despite a lack of water, even in subsequent years. All residential colonies were found in low spots of terrain or within site of a lake. Many were located along drainage ditches, beside roads, and had small ponds within or adjacent to the nesting substrate. Most of these sites seem susceptible to temporary flooding due to locally heavy precipitation. These observations are similar to other reports (Dusi 1971; Telfair 1983).

Effects of precipitation and water levels on nesting wading bird colony locations and populations, especially cattle egrets populations, are well documented (Dusi and Dusi 1968; Ogden et al. 1980; Bancroft et al. 1988; Dusi 2001; Bryan et al. 2003). In South America and Africa cattle egrets initiated breeding at the onset of the rainy season (Lowe-McConnell 1967; Siegfried 1971; Kopij 1997). Rainfall is thought to increase available nesting sites and forage for cattle egrets (Telfair 1983).

Creating preferred nesting habitat such as islands or flooded trees and shrubs is a potential management strategy not yet attempted in Central Texas. Over 60% of terrestrial wetlands have been drained in Texas and most rivers have been severely degraded by dam building and water diversion (Schmidly 2002). Created sites are most likely to be used long term if surrounding water is permanent and the nesting substrate tolerant of flooding, nutrient loading, and supportive of bird nests. The water may not need to be deep to deter ground predators (Rodgers 1987; Frederick and Collopy 1989*b*). Due to the wide variety of nesting substrate species used, herons and egrets do not appear to have a species preference (Krebs 1994; Telfair 1994; Rodgers and Smith 1995; Frederick 2002; this study). The fact that herons and egrets were attracted to flooded tree and shrub sites within 3 years of their creation supports this "build it and they will come" management hypothesis as do other observations (Post 1990; Dusi 1992). Ranchers may be especially interested in attracting colonies to their land due to the amount of insects, especially grasshoppers, consumed by cattle egrets (Siegfried 1966; Telfair 1979, 1983).

CHAPTER IV

CONCLUSIONS AND IMPLICATIONS

Large, residential, egret and heron colonies were only reported in the central part of the state, mostly within or bordering the Post Oak Savannah and Blackland Prairie ecoregions. Records of colonies to the east and along the coast of the Gulf of Mexico were in flooded trees and shrubs or on freshwater or coastal islands. A ground search found colonies in Central Texas during the breeding seasons of 2005 and 2006 in a mixture of upland/residential and wetland habitats. Colonies in flooded trees and shrubs were artificially flooded and colonized within a few years of their inundation. Drought conditions apparently precipitated abandonment of 3 flooded tree and shrub colonies that became dry between the 2005 and 2006 nesting seasons.

These records and observations suggest that egrets and herons prefer swamp and island habitat to nest and use residential areas as an alternative if preferable sites are unavailable. Many studies of small herons and egrets have documented this preference in other regions (Bancroft et al. 1988, Rodgers 1995, Parsons and Master 2000). These habitats are limited and ephemeral in Central Texas. Cattle egret colony presence and type seem to reflect availability of wetland habitats which reflects course scale rainfall patterns. Course scale wetland availability seems to dictate overall breeding distribution while fine scale availability of swamp or island habitat may determine where residential sites are utilized.

The reason that sites near human habitation are the alternative to wetland sites is unknown. The main advantage in choosing flooded sites and islands for nesting is

protection from reptilian and mammalian ground predators, especially raccoons (Dusi et al. 1971, Rodgers 1987, Frederick and Collopy 1989*b*). A likely reason for choosing residential sites as an alternative is also avoidance of ground predators over other areas, though this hypothesis has not been specifically tested. A habitat suitability model suggested that edges of developed areas were likely to be colonized, especially in combination with forest and wetland edges.

Predator prey relationships along edges and gradients of development are likely specific to species, scale, and surrounding landscape matrix type (Orians and Wittenburger 1991, Dijak and Thompson 2000, Shmidt et al. 2001). More study is necessary to determine the exact mechanism or combination of mechanisms responsible for formation of cattle egret colonies along edges of development in Central Texas.

For cattle egrets, residential colonies had on average larger population sizes, higher nest survivorship, and lower average nest fledging brood sizes than non-residential colonies, but these differences were not statistically significant. A stronger adaptive advantage might become more evident with more study as the number of colonies monitored was few and these data collected over only 2 breeding seasons.

Complete removal of vegetation eliminated nesting at a nuisance residential site and an unwanted flooded tree and shrub site. Loud noise emitted from propane cannons was effective in preventing reuse of colony sites without removing vegetation. It was observed that this disturbance must be focused within the colony to prevent reuse and the amount of repetition needed to prevent recolonization was variable, from 3 days up to 6 weeks

Creating preferred nesting habitat such as islands or flooded trees and shrubs is a potential management strategy not yet attempted in Central Texas. Over 60% of terrestrial wetlands have been drained in Texas and most rivers have been severely degraded by dam building and water diversion (Schmidly 2002). Created sites are most likely to be used long term if surrounding water is permanent and the nesting substrate tolerant of flooding, nutrient loading, and supportive of bird nests. The water may not need to be deep to deter ground predators (Rodgers 1987, Frederick and Collopy 1989*b*). Ranchers may be especially interested in attracting colonies to their land due to the amount of insects, especially grasshoppers, consumed by cattle egrets (Siegfried 1966, Telfair 1979, 1983).

The phenomenon of nuisance heronries in Central Texas is likely related to high cattle densities attracting large numbers of cattle egrets to breed, enough wetland habitat to support little blue herons and snowy egret foraging and breeding but not enough wetland habitat to provide preferred flooded tree and shrub or island habitat for nesting. Increased development and resulting fragmentation and limitation of water resources likely exacerbates this phenomenon and elevates the visibility of its effects.

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APPENDIX

Table 1—Species codes used in colony site accounts

Species name	Species code	Species name	Species code
cattle egret	CAEG	neotropical cormorant	NECO
little blue heron	LBHE	black crowned night heron	BCNH
snowy egret	SNEG	anhinga	ANHI
great egret	GREG	great blue heron	GBHE
tricolored heron	TRHE	white ibis	WHIB

Colony Site Accounts

Bellmead

COLONY SITE DESCRIPTION

County: McLennan
Ownership: private
Lat. Long.: N 31.6158, W -97.0797
Colony type: residential
Colony area: 3000 m²
Nest substrate species: post oak, juniper, mesquite, winged elm

REPRODUCTIVE SUCCESS

2005: 16 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	1760	0.585 (0.483 - 0.665, 95% CI) (106)	2.12 ± 0.84 (58)
LBHE	17	0.666* (3)	2.5 ± (0.70) (2)
SNEG	8	0.500* (4)	3.5 ± (0.70) (2)

2006: 12 visits

*Apparent nest survival (Mayfield 1975)

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	924	0.353 (0.259 - 0.457, 95% CI) (75)	1.91 ± 0.75 (22)
LBHE	34	0.429* (7)	2.00 ± 0.00 (3)
SNEG	10	0.500* (2)	2.0 (1)

Other nesting species (pairs): 2005: GREG (15), BCNH (2); 2006: GREG (60), BCNH (7)
Census technique: complete count

Colonies have existed in the city of Bellmead for decades, new sites established when previous sites were disturbed (TXCWBS 1982). This site has been active for at least 4 years in dense vegetation situated between housing lots, along a suburban road, bordering a drainage ditch.

DISTURBANCE/MANAGEMENT
Red shouldered hawks, turkey vultures, and black vultures regularly visited the colony. In addition, occurrences of mammalian predation were inferred by examining adult bird carcasses and feathers (Elbroch 2005). The field neighboring the site has been bulldozed and heavy equipment was operated within 5 m of nesting birds. Home owners near the colony cleared their properties of low, dense foliage, and employed propane cannons at a distance of approximately 100 m. When noise discharged, birds would fly from their perches momentarily before returning to nesting activities.

College Station

COLONY SITE DESCRIPTION

County: Brazos
Ownership: private
Lat. Long.: N 30.5674, W -96.3584
Colony type: artificially flooded vegetation
Colony area: 3750 m²
Nest substrate species: juniper, yaupon, post oak, elm sp.

REPRODUCTIVE SUCCESS

2005: 16 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	922	0.382 (0.300 - 0.472, 95% CI) (112)	2.23 ± 0.57 (40)
LBHE	12	0.750* (4)	3.00 ± 1.73 (3)
SNEG	7	0.666* (6)	1.67 ± 1.56 (4)

2006: 12 visits

*Apparent nest survival (Mayfield 1975)

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	1056	0.523 (0.403 - 0.642, 95% CI) (66)	2.97± 0.57 (40)
LBHE	16	0.333* (3)	3.0 (1)
SNEG	13	0.00* (1)	no data

Other nesting species (pairs) 2005: GREG (1), ANHI (5); 2006: GREG (7), ANHI (9)
Census technique: complete count

This colony was established in 2004, the breeding season after two ponds were created by the landowner. Resulting flooded vegetation was used as nesting substrate. The smaller of 2 ponds was used in 2004, but was abandoned after nesting was initiated in 2005 when water levels receded and the pond dried. Nesting moved to the larger pond where it continued in 2006. These ponds have resident alligators.

DISTURBANCE/MANAGEMENT

Evidence of predation and observation of potential predators were frequent at this site. The landowner observed crows predating eggs and dozens of empty eggs were collected with holes suggesting corvid predation. Many piles of feathers suggesting both mammalian and avian predation were observed. Incidents of barred owl vocalizations, raccoon tracks, and red shoulder hawk flyovers were common. Adult herons and egrets were observed dead on nests, apparently due to predator activity. Feral hogs were seen entering the colony but no apparent response was elicited by the birds. The land owner trapped raccoons, river otters, and coyotes on the property and suspected that great horned owls were killing birds. A nearby airport causes disturbance, birds temporarily flush when planes fly over the colony.

Elroy

COLONY SITE DESCRIPTION

County: Travis
Ownership: private
Lat. Long.: N 30.1362, W -97.6155
Colony type: residential
Colony area: 16,900 m^2
Nest substrate species: live oak, yaupon

REPRODUCTIVE SUCCESS

2005: 10 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	10698	0.745 (0.655 – 0.823, 95% CI) (132)	2.36 ± 0.79 (103)
LBHE	50	0.750 * (4)	3.0± 0.00 (3)
SNEG	20	0.00* (1)	no data

*Apparent nest survival (Mayfield 1975)

Other nesting species (pairs): GREG (36), ANHI (2)
Census technique: density estimate

This colony was established in a stand of trees of on the property of an active cattle ranch adjacent to a road. 2005 was either the third or fourth consecutive year of heron and egret nesting at this site. Much of the vegetation was defoliated due to the nesting birds. Across the street and surrounding the ranch is a residential neighborhood. A small pond is immediately adjacent to the colony.

DISTURBANCE/MANAGEMENT
Turkey vultures and black vultures were regularly seen in and around the colony. Red-tailed hawk and crested caracara were also observed. Punctured eggs suggesting corvid predation were collected from the edge of the colony. Domestic dogs were observed in and around the colony on several occasions.

In April of 2006 propane cannons were placed in the colony and no nesting occurred at this site that year. A colony near Cedar Creek, about 9.4 miles southeast of Elroy, was established in late April 2006.

Harwood

COLONY SITE DESCRIPTION

County: Gonzales
Ownership: private
Lat. Long.: N 29.6657, W -97.5014
Colony type: residential
Colony area: 13,742 m^2
Nest substrate species: hackberry, post oak

REPRODUCTIVE SUCCESS

2005: 9 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	10,996	0.863 (0.772 - 0.929, 95% CI) (90)	2.13 ± 0.74 (79)
LBHE	27	(0)	no data
SNEG	0		

Other nesting species (pairs): none

*Apparent nest survival (Mayfield 1975)

Census technique: density estimate

According to local residents, a colony had been in this small ranching town at a different site in 2004, and potentially in prior years. Birds nested in very dense small trees and shrubs, mostly hackberry. A small pond about 950 m^2 in area was within the colony. This dense patch was rectangular, bordered by roads and railroad tracks with mobile homes within 100 m of nesting birds.

DISTURBANCE/MANAGEMENT
Evidence of egg predation was observed, but no evidence of large scale nest failure due to predation was seen. Domestic dogs and cats were observed in and around the colony. 17 intact dead adult cattle egrets were found dead within a small area near the pond within the colony. Their cause of death is unknown

All of the nesting vegetation at this site was removed in the winter of 2005-2006 using a bulldozer. No nesting occurred in town in 2006. As the breeding season progressed very few birds were observed foraging in pastures within 10 miles of town, suggesting no large colonies were established in this area in 2006. Hundreds of birds were observed roosting in town in May 2006, but did not nest even though very similar vegetation was intact near and adjacent to the colony site used the previous year.

Antioch

COLONY SITE DESCRIPTION

County: Houston
Ownership: private
Lat. Long.: N 31.1431, W -95.7317
Colony type: artificially flooded vegetation
Colony area: 165,000 m^2
Nest substrate species: no data

REPRODUCTIVE SUCCESS

2005: 4 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	4,830	0.700* (30)	2.60 ± 0.50 (20)
LBHE	2	No data	No data
SNEG	0		

Other nesting species (pairs): WHIB (1)
Census technique: complete count

*Apparent nest survival (Mayfield 1975)

This colony is located approximately 1500 m east of the Trinity River, in its floodplain. It is on agricultural land where cotton is grown. Surrounding properties are farmed or grazed by cattle. Nesting vegetation was flooded in 2003 for recreational purposes. Herons and egrets nested there in 2004 and 2005. No nesting occurred there in 2006, likely due to a lower water level in the pond. Very little cattle egret activity was observed in the surrounding pastures in 2006 and no colonies were discovered nearby. Daily survivorship was not calculated in 2005 because colony access was granted too late in the season. Yellow-crowned night heron juveniles were observed may have been reared in this colony.

DISTURBANCE/MANAGEMENT

Alligators were residents of this pond. There was evidence of predation, likely avian, with adult body parts found in the cotton field surrounding the colony. It was also observed that a tree very close to shore was completely abandoned after nesting was initiated. Red-tailed hawks and feral hogs were observed at this site.

Robinson

COLONY SITE DESCRIPTION

County: McLennan
Ownership: private
Lat. Long.: N 31.4857, W -97.0670
Colony type: artificially flooded vegetation
Colony area: 9600 m^2
Nest substrate species: no data

REPRODUCTIVE SUCCESS

2006: 7 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	6364	0.748 (0.613 - 0.856), 95% CI) (71)	2.10 ± (0.72) (56)
LBHE	10	1.00 * (1)	2.0 (1)
SNEG	21	1.00* (6)	1.60 ± (0.89) (5)

Other nesting species (pairs): GREG (6), ANHI (1), WHIB (1), NECO (8), GBHE
Census technique: density estimate

Colony is located in trees flooded by a pond created by a gravel mining operation. Water levels were higher than in previous years due to a change in water management regime and localized heavy rain in late April 2006. During this storm a tornado went through the area possibly disturbing a previously colonized site.

*Apparent nest survival (Mayfield 1975)

DISTURBANCE/MANAGEMENT

This site seemed relatively undisturbed by predators due to little evidence of predation being observed. However, some nests were within 5 m to operating heavy machinery and scrap concrete dumping. Nesting birds were not disturbed unless these activities were very close, and they seemed to resume normal nesting activities soon after activity ceased. Water levels in this pond are managed irrespective to the needs of nesting birds.

Cedar Creek

COLONY SITE DESCRIPTION

County: Bastrop
Ownership: private
Lat. Long.: N 30.0131, W -97.5472
Colony type: residential
Colony area: 7,195 m^2
Nest substrate species: post oak, juniper, winged elm

REPRODUCTIVE SUCCESS

2006: 11 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	5756	0.754 (.659 – 0.835, 95% CI) (89)	2.34 ± .59 (65)
LBHE	71	0.438 * (16)	1.71 ± 0.49 (7)
SNEG	15	0.00* (1)	

Other nesting species (pairs): GREG (2)
Census technique: density estimate

This colony was established in 2006 in thick trees and shrubs centered on a lot occupied by a vacant house and spreading onto adjacent properties. The habitat patch is bordered on one side by a road and drainage ditch and another by a fence line.

DISTURBANCE/MANAGEMENT
Human disturbance, in the form of a person using a drum to attempt to scare the birds and landscapers operating equipment near nests transpired. No large scale nest abandonment is known to have occurred due to human disturbance. There were piles of feathers and broken eggs suggesting both mammalian and avian predation discovered in a portion of the colony. Raccoons, possums, and coyotes inhabit this area. Red-tailed hawks and American crows were observed. Domestic dogs entered the colony.

*Apparent nest survival (Mayfield 1975)

Lake Conroe

COLONY SITE DESCRIPTION

County: Montgomery
Ownership: unknown
Lat. Long.: N 30.4032, W -95.5738
Colony type: island
Colony area: 2460 m^2
Nest substrate species: juniper, willow sp.

REPRODUCTIVE SUCCESS

2006: 10 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	903	0.818 (.696 - .901, 95% CI) (57)	2.09 ± .72 (46)
LBHE	0		
SNEG	1	0.00* (1)	

Other nesting species (pairs): NECO (38), GBHE (10), TRHE (1)
Census technique: complete count

This colony is located on an island approximately 115 m from the eastern shore of Lake Conroe. Herons and egrets have nested there for the past several years, but the year of colony establishment is unknown. The nesting substrate has been degraded by nesting and several trees were blown down during a storm in 2006.

DISTURBANCE/MANAGEMENT

Fireworks were launched from the shore toward the island from the eastern shore. This disturbance was not witnessed. Several adult cattle egret carcasses were found on shore, apparently brought there by avian predators.

*Apparent nest survival (Mayfield 1975)

UT Southwestern Medical Center

COLONY SITE DESCRIPTION

County: Dallas
Ownership: public
Lat. Long.: N 32.8136, W -96.8398
Colony type: urban
Colony area: 20,625 m^2
Nest substrate species: post oak, live oak, black willow, juniper, sugar hackberry, cedar elm, china berry, red mulberry

REPRODUCTIVE SUCCESS

2005: 0 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	688	no data	no data
LBHE	14	no data	no data
SNEG	11	no data	no data

2006: 15 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	1620	0.691 (0.598 - 0.774, 95% CI) (100)	1.76 ± 0.58 (67)
LBHE	16	0.666* (3)	2.0 ± 1.0 (2)
SNEG	19	0.625* (16)	2.20 ± 0.79 (10)

Other nesting species (pairs): 2005: GREG (452), BCNH (16), TRHE (2) 2006: GREG (502), BCNH (15), TRHE (2), WHIB (7), ANHI (5)
Census technique: complete count (Scott Clark)

This colony is in the middle of urban Dallas on the campus of the University of Texas Southwestern Medical Center. The colony has been active since at least 1973.

DISTURBANCE/MANAGEMENT

Potential predators observed the colony were limited to a domestic cat, blue jays, fire ants, and people. The colony is posted as a nature reserve and no trespassing is permitted during the nesting season.

*Apparent nest survival (Mayfield 1975)

Lake Alvarado

COLONY SITE DESCRIPTION

County: Johnson
Ownership: private
Lat. Long.: N 32.3880, W -97.2553
Colony type: residential
Colony area: 525 m^2
Nest substrate species: live oak, elm sp.

REPRODUCTIVE SUCCESS

2006: 8 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	400	0.663 (0.385 - 0.880, 95% CI) (27)	2.05 ± 0.67 (21)
LBHE	3	no data	no data
SNEG	20	no data	no data

Other nesting species (pairs): none
Census technique: visual estimate, density estimate

This colony is in a neighborhood about 215 m from Lake Alvarado and is surrounded by houses. 2006 was the first year birds nested at this site.

DISTURBANCE/MANAGEMENT
A few dead adult cattle egrets and scattered feathers were observed along the road.

Lewisville: Lake Park

COLONY SITE DESCRIPTION

County: Denton
Ownership: public
Lat. Long.: N 33.0758, W -97.0056
Colony type: residential
Colony area: 1750 m^2
Nest substrate species: post oak, ash sp., elm sp.

*Apparent nest survival (Mayfield 1975)

REPRODUCTIVE SUCCESS

2006: 8 visits

Nesting species	Nesting pairs	Seasonal nest survivorship (*n*)	Avg. nest fledging brood size (*n*)
CAEG	400	0.876 (0.765 – 0.949, 95% CI) (59)	1.83 ± 0.59 (52)
LBHE	1	no data	no data
SNEG	5	1.00* (4)	2.0 ± 0.00 (4)

Other nesting species (pairs): none
Census technique: visual estimate

Colony is located in thick trees and shrubs bordering the parking lot of a public park. The park is mainly used for recreation such as softball. Surrounding the park is a residential neighborhood and Lake Lewisville is 140m away. 2006 was the first year birds nested at this site.

DISTURBANCE/MANAGEMENT
An unidentified hawk species and turkey vultures were observed near the colony. The colony is near human activity such as moving cars and recreation. Concerned residents placed orange fencing in front of the colony and a plastic pool filled with water within the colony for the birds. Fledglings used this pool extensively for drinking and bathing

*Apparent nest survival (Mayfield 1975)

Colonies with more limited data

North Katy

COLONY SITE DESCRIPTION

County: Harris
Ownership: private
Lat. Long.: N 29.8740, W -95.7990
Colony type: artificially flooded vegetation
Colony area: 12,000 m^2
Nest substrate species: black willow, cottonwood

NESTING DATA

2005: 1 visit

Nesting species	Nesting pairs
CAEG	7,596
LBHE	yes
SNEG	yes

Other nesting species (pairs): BCNH, WHIB
Census technique: density estimate

This colony was discovered too late in the season to effectively evaluate reproductive success or estimate nesting pairs for species other than cattle egret. The colony is on an island surrounded by levies. These levies collect water to attract waterfowl. Surrounding area used by cattle for grazing. It is unknown if this site was active prior to 2005. In 2006 water levels dropped and no heron and egret nesting occurred at this site and no colonies were discovered in the vicinity. No evidence of predation was observed. The picture above is from May 2006, showing the low water levels. Raccoon tracks were observed in the mud surrounding the island in 2006.

*Apparent nest survival (Mayfield 1975)

Clear Creek Natural Heritage Center

COLONY SITE DESCRIPTION

County: Denton
Ownership: public
Lat. Long.: N 33.2562, W -97.0505
Colony type: artificially flooded vegetation
Colony area: 700 m^2
Nest substrate species: white ash

NESTING DATA

2005: 0 visits

Nesting species	Nesting pairs
CAEG	763
LBHE	50
SNEG	35

Other nesting species (pairs): GREG (154), ANHI (3), NECO (4), GBHE (8)
Census technique: complete count (Geogette Guernsey)

Clear Creek Natural Heritage Center was created by the city of Denton and the U.S. Army Corps of Engineers. Herons and egrets nest in trees that were flooded in order to create wetland habitat for the park. This colony was active in 2005, but due to low water levels, was effectively not utilized in 2006. Great blue herons, great egrets, little blue herons, and snowy egrets gathered with some nesting reported in April 2006, but by May the pond had dried and no nesting was observed.

San Antonio Zoo

No Photo

COLONY SITE DESCRIPTION

County: Bexar
Ownership: public
Lat. Long.: N 29.4635, W -98.4715
Colony type: urban

NESTING DATA

2005: 2 visits

*Apparent nest survival (Mayfield 1975)

Nesting species	Nesting pairs	
CAEG	257	Other nesting species (pairs): GREG (56)
LBHE	16	Census technique: complete count
SNEG	2	

This colony is located on the grounds of the San Antonio Zoo, above the exotic wading birds exhibit. These birds receive food fed to the display birds and likely gain protection from predators by being within the fenced area of the zoo. The colony is a nuisance because nesting birds defecate on patrons. Attempts have been made to scare the birds via daily exposure to pyrotechnics, but these efforts have not been consistent or successful. In 2006 most of the colony moved to a non-public area of zoo property, likely due to disturbance caused by construction.

Fairview

COLONY SITE DESCRIPTION

County: Collin
Ownership: private
Lat. Long.: N 33.1235, W -96.6077
Colony type: residential
Colony area: 450 m^2
Nest substrate species: live oak, elm sp.

2006: 1 visit

The Fairview colony was active in 2006 in a dense stand of live oak and elm on an undeveloped lot of a new housing complex. The developer plans to thin or remove vegetation after the breeding birds depart, making future nesting unlikely. Cattle egrets and little blue herons nested there, but no population estimate was made. Colony area makes it likely that less than 500 pairs of birds nested there.

Celeste

COLONY SITE DESCRIPTION

County: Hunt
Ownership: private
Lat. Long.: N 33.2711, W -96.2150
Colony type: artificially flooded vegetation
Colony area: no data
Nest substrate species: no data

*Apparent nest survival (Mayfield 1975)

This site became active in 2005, 3 years after a pond was created by the landowner. During the following winter nesting vegetation was removed and there was no known nesting in the vicinity during 2006.

Telfair Islands

COLONY SITE DESCRIPTION

County: Henderon
Ownership: public
Lat. Long.: N 32.3208, W -96.1829
Colony type: island
Colony area: 35, 152 m^2 (both islands combined)
Nest substrate species: mostly chinaberry

This colony consists of 2 islands in Cedar Creek Reservoir. It is owned and managed by the federal government as part of a wildlife management area. No nest census was performed in 2005 or 2006 due to low water levels (Tim Folts, pers. comm.). In the past it has supported thousands of nesting herons and egrets including cattle egrets, snowy egrets, great egrets, neotropic cormorants, tri-colored herons, and black-crowned night herons. For more detailed information on this site see Telfair and Bister (2004).

New Waverly

No Photo

COLONY SITE DESCRIPTION

County: Walker
Ownership: private
Lat. Long.: N 30.5427, W -95.4052
Colony type: artificially flooded trees
Colony area: 100 m^2
Nest substrate species: bald cypress

According to the landowner, about 20 pairs of cattle egrets began nesting in 2005 soon after a bald cypress was planted in his pond. He was able to deter their nesting using noise. An alligator uses this pond.

*Apparent nest survival (Mayfield 1975)

Cameron

COLONY SITE DESCRIPTION

County: Milam
Ownership: private
Lat. Long.: N 30.8608, W -96.9922
Colony type: residential
Colony area: no data
Nest substrate species: post oak, ash, crepe myrtle tree (exotic)

REPRODUCTIVE SUCCESS

No data: inactive 2005 and 2006
nesting species (previous years): CAEG, LBHE, SNEG, GREG

Description: Large colonies of herons and egrets were established in the small city of Cameron since at least 1992 at a minimum of 5 different sites in various years. The birds would use a site until the vegetation was removed during the non-breeding season or were disturbed with noise. The site used in 2003 and 2004 was on the property of a tree nursery in a patch of dense vegetation, mostly exotics. The nursery is along a road on the outskirts of town.

DISTURBANCE/MANAGEMENT

In 2005 2 propane cannons were placed in the colony upon the bird's arrival in April. These cannons were in operation for nearly 2 months. During this span, birds were observed attempting to return to this site at dusk to roost, only to be disturbed by the noise and roost elsewhere. Propane cannons were also employed in 2006. No large heron and egret colonies were established in this area in 2005 or 2006.

*Apparent nest survival (Mayfield 1975)

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PEER-REVIEWED PUBLICATIONS

Kelly, J. P., K. Etienne, C. Strong, M. McCaustland, and M. L. Parkes. 2007. Status, trends and implications for the conservation of heron and egret nesting colonies in the San Francisco Bay Area. Waterbirds in press.

Parkes, M. L. 2005. Inter-nest infanticide in Ardeids. Waterbirds 28: 256-257.

ADDITIONAL PUBLICATIONS

Kelly, J. P., K. Etienne, C. Strong, M. McCaustland, and M. L. Parkes. 2007. Annotated Atlas and Implications for the Conservation of Heron and Egret Nesting Colonies in the San Francisco Bay Area. Point Reyes Printing, Point Reyes CA. 236p. http://www.egret.org/atlas.html

Parkes, M. L., and K. Heath. 2002. Great Captains Island heron and egret study. Greenwich (CT): Audubon Greenwich. 47p. http://www.audubon.org/local/ sanctuary/greenwich/ Documents/GtCaptainsIslanFinalReport2002.pdf